CONTRIBUTIONS FROM THE LABORATORY OF VERTEBRATE BIOLOGY

UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN

Number 64 February, 1954

THE SOIL ARTHROPODS OF A FIELD IN SOUTHERN MICHIGAN: A STUDY IN COMMUNITY ECOLOGY

By NELSON G. HAIRSTON and GEORGE W. BYERS

Accepted for publication April 7, 1953

CONTENTS

Introduction 1
Description of the Field 3
Methods 3
Numerical Abundance of Microarthropods 4
Vertical Distribution of Microarthropods in the Soil 6
Distribution on the Field 8
Seasonal Variations in Numbers and Vertical Distribution 16
Relationship Between Numbers of Individuals and of Species 25
Summary and Conclusions 34
Literature Cited 35

INTRODUCTION

PROBLEMS of analyzing a natural community are so great and so numerous that one would seem foolhardy to attempt their solution. Nevertheless, the attempt is made worth while by the fact that the natural community represents the major framework for a great deal of ecological thought. We use grandiose terms and abstract ideas in speaking of major communities, biocoenoses, associations, and so forth, and then quietly go back to our work on the ecology of a few taxonomically limited species. Plant ecologists and limnologists have made the major contributions to current ideas concerning communities. The reason is not far to seek. The student of the animals of terrestrial communities has no Gray's Manual nor Ward and Whipple to orient him taxonomically. As a consequence, such an ecologist follows one of three approaches: (1) He selects a small taxonomic group, becomes proficient in naming the members of that group, and works out their ecology in such detail as he can; (2) he lumps everything together that he does not recognize; (3) he sends his material to competent taxonomists for identification. The third approach would seem to be the best course, except for a few obstacles. The taxonomists are imposed upon; there are many groups not covered by competent taxonomists; and the amount of time involved is enormous. As the result, when the ecologist begins to write up his work he finds that for some groups he has specific or even subspecific identifications, but for other groups the identifications may be only to genus or other higher categories. Unfortunately, ecological importance and taxonomic certification may thus eventually have an inverse relationship.

In the present work we have attempted to cut the Gordian knot of taxonomy by sorting out the kinds of small arthropods that were recovered by Tullgren extractions, making no effort to identify them beyond higher categories. Below this level they are referred to by letter and number. The letter indicates the presumed next lower category; the number refers to the order in which the kind appeared in the process of counting. Thus, mite P1 is the first kind of Parasitoid found; Beetle St3, the third kind of Staphylinid, and so forth. The kinds were sorted with extreme care, and mounted specimens were used in checking identities. We are confident that the kinds recognized were kept consistent. In order to provide a basis for reference, specimens of each kind will be deposited in the Museum of Zoology of the University of Michigan. This procedure, although admittedly less desirable than perfect taxonomic identification, we believe to be superior to methods involving the lumping of numbers of species. The real question, of course, is whether the kinds that we recognize are the equivalents of the true species present. We believe that the great majority of them are. It may be argued that confusion will occur between the young and adults of the same species, but over 95 per cent of the individuals counted were either mites or ametabolous insects; the young in these cases are usually similar to the adults. Life-history stages have presented no problem serious enough to bias the results. It may also be argued that one unfamiliar with specific characters would not know what to look for in sorting the kinds. This is undoubtedly true in general, but many competent taxonomists are agreed that for a restricted locality the problem of sorting is greatly reduced. Granting some errors, particularly with metabolous insects and sexually dimorphic species, we believe that they are few and unimportant to the study as a whole. Throughout the remainder of this paper we shall assume that the organisms are sorted correctly to species, and we shall refer to them accordingly.

Acknowledgments

This study was supported by a grant from the Horace H. Rackham School of Graduate Studies: Faculty Research Fund, Project No. 739. We are indebted to J. Speed Rogers, Director of the Edwin S. George Reserve, for making the facilities of the Reserve available. Irving J. Cantrall, Curator of the Reserve, assisted in many aspects of the field work. Frederick E. Smith kindly spent many hours with the senior author, discussing the statistical analyses.

DESCRIPTION OF THE FIELD

The abandoned field upon which these observations were carried out is situated on the Edwin S. George Reserve in the southernmost part of Livingston County, Michigan. The Reserve has belonged to the University of Michigan since 1930 and has not been disturbed since that date. The field was probably used as pasture prior to its acquisition by the University and has apparently not been ploughed for at least 50 years (Evans and Cain, 1952). Rectangular, and oriented approximately north and south, it contains 14.5 - 15 acres (Fig. 3). The vegetation is principally grass, with a scattering of juniper and hawthorn shrubs. The surface is flat, broken in 11 places by shallow depressions, the vegetation of which is markedly different, being a dense mat of bluegrass (Poa pratensis), with few other herbs. Detailed studies of the vegetation have been undertaken, and some of the results have been published (Evans and Cain, 1952; Evans, 1952; Cain and Evans, 1952).

The field is on upland glacial outwash; the soil has been classified as sandy loam of the Fox or Bellefontaine series. The major part of the sod ends at about 1.5 inches; below this, there is a zone of the same dark brown, but of coarser texture, extending to 7.5 - 8 inches. This band ends abruptly, giving way to an orange sand containing waterworn stones up to 3 inches in diameter, most of them about 1 inch. The orange sand gradually becomes darker and extends down to 32-40 inches. It gives way to a sandy gravel which is light gray to tan. This is again an abrupt change. The gravel goes to at least 48 inches; it is the only layer that gives a positive reaction for carbonate. The soil profile in the depressions differs principally in the greatly increased thickness of the different layers.

METHODS

In drawing samples from the field, a wide strip around the edge was ignored because of the invasion of small oaks from the surrounding forest. Similarly, no samples were taken from beneath the two large hickory trees that stand isolated on the field. The depressions mentioned above were sampled separately and are not included in this report. A 60-foot trap grid had been set up on the field, and the stakes for these traps served as convenient orienting points for locating the soil samples. The location of each sample was determined by drawing a number from each of three jars, thus assuring a random distribution of samples over the field. To help the interested reader locate individual samples on the maps (Figs. 3, 5, 6), the details of the method will be given. The first drawing was for the trap at the southeast corner of a 60-foot square; the second was for a foot-wide strip running east and west within the square, starting from its northern boundary; the third was for a single square foot within this strip, starting from its western edge. Thus, the first sample on Table I, designated as B4-1450, lies in the square defined by trap positions A4, A5, B4, and B5; it is on the 14th foot-wide strip south of the line A4 - A5, and is in the 50th square foot east of the line A5 - B5.

When the square foot to be sampled had been located, the vegetation was clipped flush with the ground. A cylindrical sample 5 inches in diameter and 8.5 inches deep was taken from the center of the clipped area. The sampling device, which we are tempted to call a geotome (Schmidt, 1946), consists of a 6-inch length of 5-inch steel pipe, sharpened at one end and split lengthwise. The two halves are held together by means of a removable metal band that fits into a groove machined around the pipe. Over the top of the soil sampler is fitted a metal cap onto which has been welded a 3-foot length of 1-inch pipe. The cap serves to take the blows from a 20-pound weight of the same shape. The weight is fitted with a short length of larger pipe, which slides up and down over the 1-inch pipe as the weight is raised and dropped, driving the sampler into the ground. With this instrument it is possible to take samples from completely frozen soil. After the sampler had been driven into the ground, it was dug out, and the two halves were separated in such a way that the soil remained in one of them. The sample was then divided vertically at 1.5 and 5 inches from the surface, and the subsamples placed in coffee cans for transportation into the laboratory. Tullgren extractions were carried out by placing the soil in funnels over which were suspended 25-watt light bulbs. A series of 20 funnels enabled us to extract all subsamples simultaneously, a procedure that is greatly to be preferred to storing part of the samples while others are being extracted.

Two samples were taken each week from September 9, 1949, to September 2, 1950, with a few exceptions due to weather or scheduling difficulties. Thirty-five of the samples, taken at intervals during the entire year, have been sorted and counted; the results are given in Table I. One of these 35 samples was taken to the full depth of the soil. Three similar samples, the locations of which were arbitrarily selected close to the first, have been included with it in Table II. These three have been omitted from Table I and from the statistical aspects of the study because their selection was not random. The results from the total of 38 samples form the basis of this paper. It will be noted (Table I) that one of each pair of samples is represented by the animals extracted from the vegetation clipped from the square foot sampled, in addition to the soil fauna. Our attention has been focused upon the animals from the soil, and all of the following observations apply only to them. They are all members of the phylum Arthropoda; a few nematodes were obtained, but since the extraction method used is unsatisfactory for collecting nematodes, they have not been included.

NUMERICAL ABUNDANCE OF MICROARTHROPODS

From the 35 randomly collected samples a total of 74,572 organisms was counted. As will be shown below, about two-thirds of the extractable arthropods occur within the top 8.5 inches taken for these samples.

After making the necessary calculations, we arrived at an estimated population of 259,304 per square meter. This figure is astonishingly close to the 263,658 per square meter reported for English pasture soil by Salt, Hollick, Raw, and Brian (1948). These authors estimated that they lost enough specimens to make a total population of 351,480, which they said was minimal because of further loss of very small specimens. Their samples were taken in November, which is a time of maximal abundance of these forms. If the four November samples are considered separately, they are found to have an average of 3479 microarthropods in the top 8.5 inches of soil. This represents a total for all depths of 423,290 per square meter, a figure that is more closely comparable with that of the authors referred to above. The agreement is the more remarkable because of the different extraction methods used: Tullgren funnels in our work, and washing through a series of sieves in theirs. Such an exact agreement may be spurious because of differences between localities and extraction methods, but Macfadyen (1952), using Tullgren extractions, reported an annual average of 157,000 mites and collembolans per square meter from the top 5 cm. in Molinia tussocks in a fen. This figure is even closer to ours and that of Salt and others than it appears, as it does not include organisms from deeper levels. Macfadyen stated that the number of these varied, but that they made up an appreciable fraction of the total, especially in winter. Using his figures to make necessary additions, we arrived at estimated populations of 111,440 in October, 458,490 in February, and 250,710 in May, not including nonoribatoid mites below 5 cm.

The three areas thus support distinctly comparable numbers of microarthropods. All estimates of numbers are considerably higher than had been reported previously. This agreement among pastured areas in the temperate zone invites comparison with other areas. Comparing pastured with forested areas is difficult because there seems to be little agreement between studies in forests. Thus, Allee, Emerson, Park, Park, and Schmidt (1949) reported 2000-3500 microarthropods per square meter of leaf mold in Illinois forest, Pearse (1946) reported an average of 18,503 per square meter of leaf mold and 5 inches of soil in North Carolina, and Hoffmann, Townes, Swift, and Sailer (1949) reported 105,044 per square meter in Pennsylvania (litter plus 1 inch of humus). Since these represent a 50-fold difference, about all one can say is that the estimates are less than comparable figures for pastures in the same latitudes, not more, as is stated by Allee and others (1949: 488), although it is clear that complete soil samples from forests are needed in order to obtain the confidence that repeatability provides.

Salt (1952) compared the soil faunas of English and tropical African pastures and found that soil arthropods are about twice as numerous in the former as in the latter. E. C. Williams (1941) reported an average of 9,822 organisms per square meter in a Panama rain forest. He collected only the leaf litter and the "loose soil on the surface." Since Pearse found 55-74 per cent of his organisms in this fraction, the two figures are comparable, although the similarity may be fortuitous, considering the above-noted range of values quoted for temperate forests. In any event, the tropical area apparently has the lesser population. These observations contradict the statements in Allee, Emerson, Park, Park, and Schmidt (1949: 473, 488) that these animals are more numerous in the tropics than in more northern latitudes. Their tentative conclusions are based mostly on early work, which was, as Salt and his co-workers stated, quite erroneous as to the total population. The facts reviewed and presented above are similar to the observations reported in Sverdrup, Johnson, and Fleming (1946) that marine plankton organisms are more numerous in high than in low latitudes. In spite of the difference in abundance, however, the turnover rate may be so much higher in the tropics that there is ample compensation for the difference in the standing crop, especially in terrestrial situations.

VERTICAL DISTRIBUTION OF MICROARTHROPODS IN THE SOIL

When this study was planned, it seemed reasonable to suppose that for all practical purposes the turf alone need be considered, since previous workers were nearly unanimous in their agreement that virtually all of the microarthropods are concentrated within a short distance of the soil surface. Notable exceptions were Dowdy (1944), who found larger invertebrates distributed downward for a considerable depth, especially in winter, and Salt, Hollick, Raw, and Brian, who stated that large numbers of organisms were collected at depths between 6 and 12 inches. A study of the soil profile indicated that it would be wise to collect to the bottom of the organic soil. The depth of this layer varies from 6 to 9 inches over the upland parts of the field. Although on some grounds it would have been more reasonable to collect to the bottom of the layer wherever it occurred, the decision was made to keep sample volumes constant, and a depth of 8.5 inches was used throughout as a reasonable approximation of the total organic soil. It soon became apparent, however, that an appreciable number of the extractable organisms was in the layer from 5 to 8.5 inches deep. This meant that some animals were being missed through too shallow sampling. When the layer from 8.5 to 12 inches deep also showed considerable numbers of microarthropods, a sample (K3-6010) was undertaken that would include the whole soil profile. At a depth between 12 and 36 inches, 4-inch layers were separated as subsamples; 3-inch layers were used below 36 inches. It was found that animals could be extracted from all layers above the parent glacial drift. To judge from the four samples taken to this depth (Table II), approximately one-third of the soil arthropods occur below the standard collecting depth of 8.5 inches (Fig. 1). This fact introduces a serious bias into the data for the majority of the samples. The bias is alleviated somewhat by two facts. First, no species is confined below the 8.5-inch depth for all four complete samples; second, no species is so distributed vertically that the majority of the specimens occur below the standard collecting depth at all seasons. Only Japygid 1 has a majority of specimens below 8.5 inches in more than one of the deep samples. Thus, it seems safe to draw conclusions based on the standard samples, with a few modifications indicated by the four complete ones (see below under seasonal changes in number and distribution).

Within the top 8.5 inches of soil the great majority of species is most numerous in the turf, and they occur in diminishing numbers downward. Only 62 of the total 177 species ever show a majority of specimens below 1.5 inches, and for many of these this represents a downward migration in late winter and spring. Only 23 species are truly characteristic of the 1.5 - 8.5-inch depth throughout most of the year. Nearly all of these come to the turf in May or June.

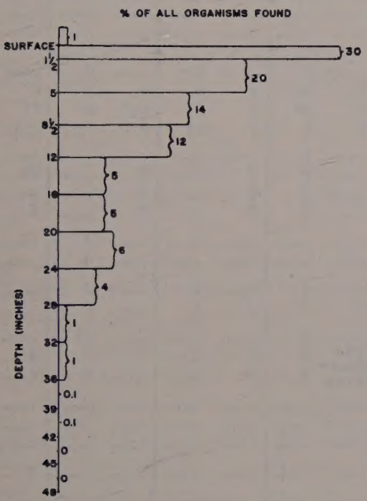

Fig. 1. Average distribution of microarthropods in a vertical transect of soil.

The finding of appreciable numbers of microarthropods at such depths is, as stated above, at variance with nearly all previous investigations. The most obvious explanation seems to lie in the physical character of the soil, which, because of its sandy nature, offers ample interstitial spaces for vertical movements. Pearse (1946) found that these animals penetrated deeper and in greater numbers in sandy soil than in clay, even though the forest was of the same type in both localities. Data on this fauna from grassy fields or meadows are, of course, not comparable with data from forests, since in the latter the soil tends to be quite shallow. Thus, the soil fauna of forests is more restricted vertically than that of grassy areas.

Before seasonal changes in numbers and vertical distribution of the soil fauna are discussed, it is necessary to consider the data as they pertain to distribution over the field and the meaning of this distribution with regard to the organization of the community.

DISTRIBUTION ON THE FIELD

When attempts were made to determine seasonal fluctuations in numbers for the various species, it became apparent that certain samples were markedly discrepant if compared with what seemed to be a seasonal trend. Thus, two samples taken in October gave lower numbers for species after species than September or November samples. It was also noted that several of the most ubiquitous species were absent from these same samples. These observations indicated the possibility that we had unwittingly taken samples from different kinds of situations and that to include observations from all in the same analysis would be unjustifiable. The sites of the different kinds of samples were not obviously different in the field, but an examination of the locations of several samples considered aberrant on the foregoing grounds indicated

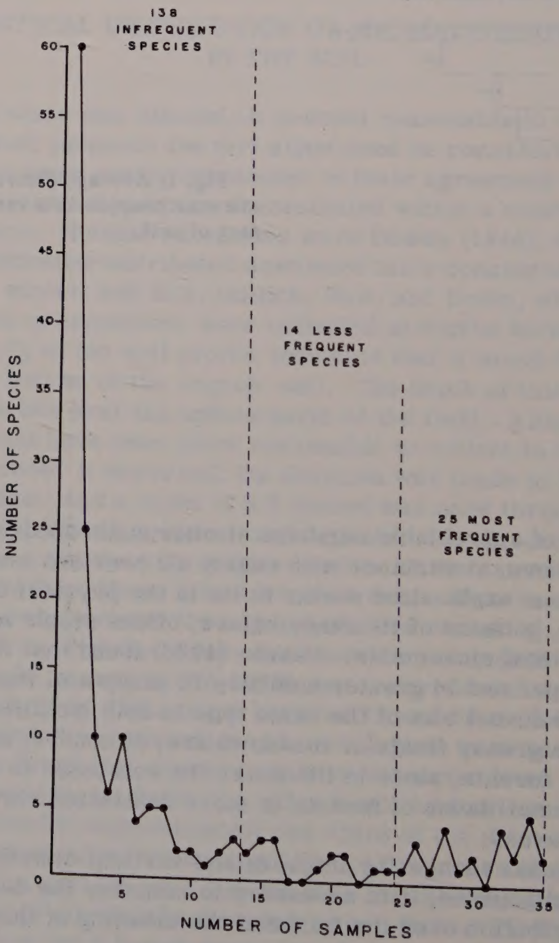

Fig. 2. Frequency of occurrence of all species of soil arthropods in 35 randomly collected samples.

TABLE I

The Numbers of All Species of Microarthropods Recorded by Sample, Season, and Depth for the Grass and Upper 8.5 Inches of Soil

For locations of samples, see text (Methods) and Figure 3.

ORGANISM	Depth (inches)	Sept. 22		Oct. 20		Oct. 27		Nov. 3		Nov. 17		Dec. 15		Jan. 5		Jan.19	Feb. 18		March 18		March 25		Apr. 8		Apr. 15		May 6		May 27		June 10		July 15		Sept. 2	
		B4	D3	D1	E5	*J1	*E5	L4	M5	K3	M2	H7	F2	J8	M6	O5	H5	*C2	*E3	*E2	*C6	*Q7	B6	*N3	*P7	K8	B6	*I2	J5	I9	N7	*Q8	N9	N2	K3	G8
		1450	2515	0623	3939	4426	2242	3616	1142	6010	1020	4526	2932	1142	1251	2841	4022	0711	1519	5854	1139	4658	1410	1205	5857	2213	1143	2607	4616	4628	3742	2507	6018	0310	0335	4853
ARACHNIDA																																				
Phalangida 1	Grass	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Araneida 2	Grass	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
3	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	1	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......
4	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
5	Grass	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	1	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......
	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
6	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1
7	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......
8	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	0	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Acarina P1	Grass	0	......	0	......	0	......	0	......	2	......	0	......	0	......	0	0	......	0	......	0	......	0	......	0	......	0	......	0	......	0	......	0	......	0	......
	0 - 1.5	5	17	10	0	0	0	10	12	18	172	38	2	28	3	3	18	......	0	5	0	0	8	0	0	0	29	2	52	88	155	89	26	18	88	184
	1.5 - 5	292	252	6	17	4	0	144	0	330	151	452	58	34	282	4	103	......	10	40	14	17	0	314	0	0	55	0	44	28	50	10	1	18	125	339
	5 - 8.5	35	63	22	0	12	1	14	2	70	0	0	26	67	51	138	81	......	0	0	1	118	16	0	11	1	3	0	5	0	0	4	3	0	61	57
P2	Grass	......	......	0	......	1	......	1	......	5	......	4	......	2	......	1	1	......	0	......	6	......	......	......	......	......	0	......	1	......	1	......	0	......	0	......
	0 - 1.5	......	14	3	1	0	3	2	......	19	......	1	3	4	......	8	1	......	0	0	1	20	......	0	......	1	4	......	3	6	8	9	5	3	21	20
	1.5 - 5	......	1	0	0	0	0	0	......	0	......	20	2	0	......	0	1	......	0	1	0	0	......	3	......	0	0	......	0	0	1	0	0	1	2	1
	5 - 8.5	......	0	0	0	0	0	0	......	0	......	0	0	0	......	0	0	......	2	0	0	0	......	0	......	0	0	......	0	0	0	0	0	0	0	0
P3	Grass	0	......	......	......	......	......	0	......	0	......	......	......	......	......	......	0	......	......	......	0	......	1	......	......	......	......	......	1	......	......	......	......	......	1	......
	0 - 1.5	1	......	......	......	......	......	4	......	4	......	......	......	......	......	......	1	......	......	......	1	......	0	......	......	......	......	......	0	......	......	......	......	......	2	......
P4	Grass	0	......	......	......	......	......	2	......	12	......	1	......	1	......	......	......	......	......	......	2	......	1	......	2	......	1	......	3	......	2	......	1	......	2	......
	0 - 1.5	3	7	......	......	......	......	6	1	9	......	0	2	0	1	......	......	......	......	......	0	......	0	......	1	1	0	1	0	......	1	......	13	5	1	3
P5	Grass	1	......	0	......	1	......	0	......	6	......	0	......	1	......	0	0	......	0	......	2	......	10	......	......	......	3	......	0	......	5	......	0	......	1	......
	0 - 1.5	10	5	7	......	0	......	2	1	9	1	1	3	1	1	1	5	1	12	1	0	6	1	......	......	1	9	3	1	1	5	......	3	......	3	2
	1.5 - 5	0	0	0	......	0	......	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	......	......	0	0	0	0	1	0	......	0	......	0	0
P8	0 - 1.5	......	......	5	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	1.5 - 5	......	......	0	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	5 - 8.5	......	......	0	......	2	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
P9	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	2	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......
P10	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......
01	Grass	0	......	11	......	9	......	8	......	3	......	138	......	21	......	87	0	......	0	......	3	......	45	......	36	......	51	......	108	......	14	......	0	......	36	......
	0 - 1.5	29	101	115	58	9	7	694	202	68	157	178	187	308	66	151	294	23	122	31	67	377	234	7	43	92	334	202	458	404	423	672	1021	559	257	570
	1.5 - 5	147	593	205	772	46	3	874	13	264	113	1034	243	180	1091	87	324	0	12	71	73	525	9	771	25	59	433	433	43	109	44	200	69	61	129	197
	5 - 8.5	235	147	420	1	572	11	379	45	402	4	18	899	1297	367	473	335	0	2	6	0	51	512	0	247	107	101	8	121	0	3	38	36	38	333	513
02	Grass	2	......	0	......	0	......	0	......	0	......	0	......	0	......	0	0	......	0	......	0	......	10	......	1	......	0	......	7	......	0	......	0	......	0	......
	0 - 1.5	9	19	6	5	2	0	32	28	40	55	155	16	84	17	151	188	4	19	1	8	23	47	0	2	29	41	8	52	58	212	205	22	59	12	18
	1.5 - 5	169	305	1	77	5	1	124	0	77	23	145	65	3	130	23	37	0	2	43	0	9	0	334	2	10	173	4	46	10	32	74	5	56	18	168
	5 - 8.5	112	136	16	3	61	0	27	13	152	0	0	255	49	28	102	233	0	1	0	0	81	534	0	21	4	29	0	47	0	0	9	12	16	72	92
03	Grass	0	......	0	......	0	......	0	......	2	......	0	......	2	......	0	0	......	0	......	2	......	6	......	2	......	7	......	24	......	39	......	0	......	4	......
	0 - 1.5	7	13	2	1	0	......	1	7	38	10	15	46	1	5	8	18	21	40	3	13	1	6	1	0	8	9	6	19	6	8	24	2	12	18	20
	1.5 -.5	0	0	0	0	0	......	0	0	7	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	5 - 8.5	0	0	0	0	9	......	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04	Grass	......	......	......	......	0	......	3	......	5	......	10	......	44	......	3	2	......	0	......	7	......	16	......	5	......	2	......	7	......	0	......	0	......	10	......
	0 - 1.5	......	......	......	......	4	......	19	14	40	5	33	11	12	15	0	32	2	8	2	2	6	7	8	4	10	10	2	10	2	5	1	1	5	7	7
	1.5 - 5	......	......	......	......	0	......	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 - 8.5	......	......	......	......	0	......	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
05	Grass	0	......	0	......	......	......	0	......	0	......	0	......	0	......	0	0	......	0	......	0	......	0	......	......	......	1	......	4	......	1	......	0	......	0	......
	0 - 1.5	0	13	2	3	......	1	104	12	0	184	100	9	50	0	23	331	2	32	0	11	5	182	0	......	16	141	6	76	45	360	......	44	9	25	494
	1.5 - 5	18	64	0	21	......	0	18	0	5	9	106	3	0	7	0	70	0	2	6	23	29	0	95	......	0	14	0	6	2	16	......	31	13	4	35
	5 - 8.5	28	0	0	0	......	0	3	0	152	0	0	47	11	1	2	3	0	0	0	0	0	15	0	......	0	0	0	0	0	0	......	6	4	0	10
06	Grass	1	......	0	......	0	......	0	......	26	......	3	......	0	......	1	0	......	0	......	30	......	6	......	......	......	3	......	3	......	1	......	......	......	0	......
	0 - 1.5	2	74	18	......	1	......	114	14	344	80	92	12	6	1	17	18	2	183	3	155	4	18	......	......	68	29	15	12	4	6	......	......	......	35	152
	1.5 - 5	0	0	0	......	0	......	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	......	......	0	0	0	0	0	0	......	......	......	0	0
	5 - 8.5	0	0	0	......	1	......	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	......	......	0	0	0	0	0	0	......	......	......	0	0
07	Grass	......	......	......	......	......	......	1	......	5	......	1	......	3	......	......	0	......	0	......	......	......	......	......	......	......	1	......	1	......	......	......	......	......	1	......
	0 - 1.5	......	......	......	......	......	......	1	......	3	......	0	......	0	......	......	1	......	2	......	......	......	......	......	......	......	0	2	0	......	......	......	......	......	0	......

TABLE I (Cont.)

The Numbers of All Species of Microarthropods Recorded by Sample, Season, and Depth for the Grass and Upper 8.5 Inches of Soil

For locations of samples, see text (Methods) and Figure 3.

ORGANISM		Depth (inches)	Sept. 22		Oct. 20		Oct. 27		Nov. 3		Nov. 17		Dec. 15		Jan. 5		Jan. 19	Feb. 18		March 18		March 25		Apr. 8		Apr. 15		May 6		May 27		June 10		July 15		Sept. 2	
			B4 1450	D3 2515	D1 0623	E5 3939	*J1 4426	*E5 2242	L4 3616	M5 1142	K3 6010	M2 1020	H7 4526	F2 2932	J8 1142	M6 1251	O5 2841	H5 4022	*C2 0711	*E3 1519	*E2 5854	*C6 1139	*Q7 4658	B6 1410	*N3 1205	*P7 5857	K8 2213	B6 1143	*I2 2607	J5 4616	I9 4628	N7 3742	*Q8 2507	N9 6018	N2 0310	K3 0335	G8 4853
Acarina (Cont.)	08	Grass	2	......	1	......	0	......	0	......	47	......	0	......	1	......	0	0	......	98	......	1	......	2	......	1	......	2	......	22	......	1	......	1	......	1	......
		0 - 1.5	35	27	5	0	1	......	16	0	58	3	25	6	9	16	3	26	......	25	4	9	11	35	0	0	4	7	3	7	4	1	15	20	40	9	8
		1.5 - 5	116	122	1	6	6	......	1	1	0	0	53	91	0	261	0	22	......	4	7	11	4	0	9	0	0	6	0	20	30	0	0	4	8	27	10
		5 - 8.5	3	9	12	0	17	......	3	2	0	0	0	91	2	16	0	139	......	0	0	0	1	46	0	6	15	0	0	29	0	0	9	0	2	36	2
	09	Grass	0	......	24	......	38	......	65	......	50	......	61	......	39	......	89	0	......	12	......	925	......	149	......	30	......	68	......	432	......	41	......	0	......	24	......
		0 - 1.5	70	49	75	27	5	3	343	358	0	960	494	112	124	98	103	160	6	157	4	115	144	2015	1	26	29	180	147	78	45	142	108	57	79	54	227
		1.5 - 5	104	47	0	25	3	0	57	0	0	38	68	30	15	10	0	19	0	3	13	4	5	0	8	0	0	12	0	2	23	65	2	11	7	122	202
		5 - 8.5	23	8	0	0	42	0	3	1	0	0	0	38	19	14	47	89	0	0	0	0	4	0	0	1	1	11	0	1	0	0	0	0	12	25	15
	010	0 - 1.5	......	......	......	......	......	2	9	......	......	2	15	......	23	......	9	2	......	......	......	......	3	......	......	......	......	......	......	1	4	......	......	......	......	7	......
		1.5 - 5	......	......	......	......	......	0	0	......	......	0	1	......	0	......	0	0	......	......	......	......	0	......	......	......	......	......	......	0	0	......	......	......	......	0	......
	011	Grass	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	0	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......
		0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	0	12	......	2	......	......	......	......	......	......	......	......	......	0	......	......	......	......	......	......	......	......	......
	012	Grass	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		0 - 1.5	......	......	......	......	......	......	......	1	......	0	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		1.5 - 5	......	......	......	......	......	......	......	0	......	2	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	013	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	014	Grass	......	......	2	......	1	......	6	......	1	......	3	......	14	......	6	0	......	......	......	......	......	1	......	2	......	1	......	4	......	......	......	......	......	12	......
		0 - 1.5	......	0	1	......	0	......	2	0	0	......	0	......	2	......	0	1	......	......	......	......	6	0	1	0	18	2	......	3	......	......	6	......	......	0	1
		1.5 - 5	......	1	1	......	0	......	0	1	0	......	0	......	0	......	0	0	......	......	......	......	0	0	0	0	0	0	......	0	......	......	0	......	......	0	0
		5 - 8.5	......	0	0	......	0	......	0	1	0	......	0	......	0	......	0	1	......	......	......	......	0	0	0	0	0	0	......	0	......	......	0	......	......	0	0
	016	0 - 1.5	0	0	......	......	......	......	1	......	......	......	0	0	2	0	0	1	......	......	1	......	0	1	......	......	......	0	......	......	......	......	......	5	3	......	0
		1.5 - 5	13	1	......	......	......	......	3	......	......	......	6	0	0	4	0	1	......	......	2	......	6	0	......	......	......	5	......	......	......	......	......	0	3	......	10
		5 - 8.5	7	10	......	......	......	......	5	......	......	......	0	4	16	1	1	1	......	......	0	......	0	4	......	......	......	0	......	......	......	......	......	0	0	......	6
	017	Grass	......	......	......	......	......	......	......	......	......	......	0	......	......	......	0	0	......	......	......	......	......	......	......	0	......	......	......	2	......	......	......	0	......	......	......
		0 - 1.5	......	0	......	......	......	......	......	......	......	......	4	......	......	0	8	6	......	......	......	......	......	......	......	0	......	......	......	0	......	......	......	6	6	......	......
		1.5 - 5	......	2	......	......	......	......	......	......	......	......	0	......	......	1	0	10	......	......	......	......	......	......	......	1	......	......	......	0	......	......	......	23	0	......	......
		5 - 8.5	......	3	......	......	......	......	......	......	......	......	0	......	......	0	0	0	......	......	......	......	......	......	......	0	......	......	......	0	......	......	......	0	0	......	......
	018	Grass	0	......	......	......	0	......	......	......	......	......	0	......	0	......	0	......	......	0	......	......	......	......	......	......	......	......	......	162	......	16	......	......	......	6	......
		0 - 1.5	0	4	......	......	0	......	......	......	......	......	4	......	1	......	0	......	......	2	......	......	......	......	......	......	......	......	......	37	55	20	4	......	17	0	......
		1.5 - 5	3	8	......	......	0	......	......	......	......	......	0	......	0	......	0	......	......	0	......	......	......	......	......	......	......	......	......	0	1	0	0	......	0	0	......
		5 - 8.5	0	2	......	......	1	......	......	......	......	......	0	......	3	......	1	......	......	0	......	......	......	......	......	......	......	......	......	0	0	0	0	......	0	0	......
	020	0 - 1.5	......	0	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		1.5 - 5	......	1	......	......	......	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	021	Grass	......	......	0	......	......	......	1	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		0 - 1.5	......	......	1	......	......	......	20	46	......	1	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	022	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......
	023	Grass	......	......	......	......	4	......	......	......	......	......	......	......	40	......	......	......	......	......	......	6	......	28	......	......	......	2	......	1	......	......	......	......	......	......	......
		0 - 1.5	......	......	......	......	2	2	......	......	......	......	......	......	8	......	......	......	......	......	......	0	......	0	......	......	......	6	......	0	12	......	......	......	......	......	1
	024	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	4	......	......
	025	0 - 1.5	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	026	0 - 1.5	......	......	......	......	......	......	......	......	......	......	5	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		1.5 - 5	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		5 - 8.5	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	4	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	027	0 - 1.5	......	......	0	......	......	......	0	......	......	......	......	......	......	......	0	7	......	......	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	1	......
		1.5 - 5	......	......	0	......	......	......	7	......	......	......	......	......	......	......	0	3	......	......	......	......	......	......	9	......	......	......	......	......	......	......	......	......	......	0	......
		5 - 8.5	......	......	1	......	......	......	11	......	......	......	......	......	......	......	11	0	......	......	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	0	......
	028	1.5 - 5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	2
	029	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	0	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	12	......	......	......	1	......	......	......	......	3	......	......	......	......	......	......	......	......	......	......
		1.5 - 5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	3	......	......	......	0	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......
	030	5 - 8.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......
	S1	Grass	0	......	0	......	0	......	0	......	0	......	0	......	0	......	0	0	......	0	......	0	......	4	......	0	......	0	......	3	......	6	......	0	......	3	......
		0 - 1.5	12	5	10	0	1	2	29	15	123	13	100	15	2	10	1	7	......	21	13	3	0	35	0	3	5	25	......	48	9	30	......	6	11	64	39
		1.5 - 5	103	18	1	1	4	0	36	1	191	111	53	109	32	1	0	11	......	3	23	3	4	1	15	0	0	10	......	18	8	0	......	16	3	6	142
		5 - 8.5	7	11	0	0	223	0	4	2	32	0	2	24	44	0	0	80	......	0	1	0	2	21	0	0	0	0	......	1	0	0	......	1	7	11	5

TABLE I (Cont.)

The Numbers of All Species of Microarthropods Recorded by Sample, Season, and Depth for the Grass and Upper 8.5 Inches of Soil

For locations of samples, see text (Methods) and Figure 3.

ORGANISM	Depth (inches)	Sept. 22		Oct. 20		Oct. 27		Nov. 3		Nov. 17		Dec. 15		Jan. 5		Jan.19	Feb. 18		March 18		March 25		Apr. 8		Apr. 15		May 6		May 27		June 10		July 15		Sept. 2	
		B4	D3	D1	E5	*J1	*E5	L4	M5	K3	M2	H7	F2	J8	M6	O5	H5	*C2	*E3	*E2	*C6	*Q7	B6	*N3	*P7	K8	B6	*I2	J5	I9	N7	*Q8	N9	N2	K3	G8
		1450	2515	0623	3939	4426	2242	3616	1142	6010	1020	4526	2932	1142	1251	2841	4022	0711	1519	5854	1139	4658	1410	1205	5857	2213	1143	2607	4616	4628	3742	2507	6018	0310	0335	4853
Acarina (Cont.) S2	0 - 1.5	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	0	......	......	......	......	......	0	0	......	......	......	......	......	......	......	......	......	......	......	......
	1.5 - 5	......	......	......	......	......	......	......	0	......	......	......	......	......	......	......	0	......	......	......	......	......	0	1	......	......	......	......	......	......	......	......	......	......	......	......
	5 - 8.5	......	......	......	......	......	......	......	0	......	......	......	......	......	......	......	2	......	......	......	......	......	1	0	......	......	......	......	......	......	......	......	......	......	......	......
S3	5 - 8.5	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
S4	0 - 1.5	......	......	46	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
T1	Grass	0	......	0	......	1	......	0	......	4	......	0	......	1	......	2	0	......	0	......	0	......	0	......	1	......	0	......	2	......	0	......	0	......	8	......
	0 - 1.5	6	19	1	1	0	......	31	1	58	41	39	2	23	......	15	13	......	9	......	7	......	38	......	0	2	4	......	5	4	21	4	5	13	10	28
	1.5 - 5	0	0	0	0	0	......	0	0	0	0	2	0	0	......	0	0	......	0	......	0	......	0	......	0	0	0	......	0	0	0	0	0	2	0	0
	5 - 8.5	0	0	0	0	0	......	1	0	0	0	0	0	0	......	0	0	......	0	......	0	......	0	......	0	0	0	......	0	0	0	0	0	0	0	0
T2	Grass	......	......	......	......	......	......	1	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
T3	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	2	......	......	......	......	......	3	......
	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	0	1	......	......	......	......	0	......
T4	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	10	......
T5	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	2	......
	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	0	......	......	1	0	......
T6	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	17	......	18	......	3	......	......	......	......	......
	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	2	......	......	......	......	......	......	......	......	......	......	2	......	......	2	......	0	......	0	......	......	......	......	......
T7	Grass	......	......	......	......	0	......	22	......	......	......	20	......	5	......	22	0	......	8	......	22	......	7	......	36	......	11	......	99	......	1	......	0	......	3	......
	0 - 1.5	......	......	......	......	1	......	5	3	......	......	1	1	2	2	0	5	......	2	......	3	3	0	......	0	......	0	1	2	3	0	......	1	......	0	......
T8	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	2	......	......	......	......	......	......	......	......	2	......	......	......	......
T9	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	2	......	......	......	......	......	1	......
T10	Grass	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	2	......	......	......	......	......	1	......
	0 - 1.5	......	......	......	3	......	......	......	4	0	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	8	......	1	0	......	......	......	......	......	0	......
T11	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......
E1	Grass	0	......	0	......	0	......	0	......	3	......	0	......	1	......	0	0	......	0	......	0	......	1	......	1	......	2	......	2	......	0	......	0	......	1	......
	0 - 1.5	13	14	11	26	4	1	27	9	31	45	6	15	4	10	5	8	......	0	0	5	0	73	2	1	4	17	15	46	149	93	22	26	8	90	122
	1.5 - 5	7	8	10	13	5	0	39	0	21	27	18	66	1	5	0	2	......	0	2	4	0	8	7	1	12	23	2	46	32	20	30	37	77	61	38
	5 - 8.5	35	4	60	4	79	1	107	52	262	2	9	50	304	89	25	13	......	1	3	0	13	35	0	40	2	58	1	11	0	2	3	21	15	62	32
E2	Grass	......	......	0	......	......	......	0	......	0	......	0	......	......	......	0	0	......	......	......	1	......	0	......	......	......	0	......	0	......	0	......	......	......	......	......
	0 - 1.5	......	......	6	6	......	26	20	2	53	10	14	0	......	0	0	40	......	......	0	0	......	14	......	......	3	2	8	9	11	9	2	......	......	......	5
	1.5 - 5	......	......	1	0	......	1	2	0	11	2	21	0	......	1	0	3	......	......	4	3	......	0	......	......	0	1	0	4	0	0	0	......	......	......	1
	5 - 8.5	......	......	7	1	......	1	2	0	21	3	1	8	......	2	1	0	......	......	0	0	......	1	......	......	0	0	0	0	0	0	1	......	......	......	0
E3	Grass	2	......	107	......	52	......	36	......	30	......	32	......	11	......	34	0	......	0	......	13	......	12	......	4	......	7	......	5	......	8	......	0	......	6	......
	0 - 1.5	11	38	17	26	3	9	118	4	1954	81	1	8	592	17	244	619	......	2	1	27	0	18	7	1	54	63	11	36	24	93	87	43	30	89	72
	1.5 - 5	67	45	7	29	8	0	21	0	10	8	10	9	1	30	7	31	......	0	9	0	7	2	41	0	5	9	0	15	12	3	34	74	30	50	58
	5 - 8.5	5	44	21	3	25	0	19	0	0	1	0	19	20	36	3	18	......	0	0	0	6	34	0	2	2	0	3	6	0	0	2	21	7	26	54
E4	Grass	0	......	......	......	0	......	0	......	5	......	0	......	......	......	0	0	......	......	......	......	......	0	......	......	......	......	......	5	......	......	......	......	......	0	......
	0 - 1.5	2	1	......	......	0	......	2	......	61	......	3	......	......	0	0	1	......	......	......	......	......	0	......	......	......	......	2	1	4	......	......	......	3	4	8
	1.5 - 5	52	8	......	......	0	......	6	......	6	......	0	......	......	0	0	5	......	......	......	......	......	0	......	......	......	......	1	16	5	......	......	......	15	0	0
	5 - 8.5	17	1	......	......	2	......	6	......	28	......	0	......	......	1	13	16	......	......	......	......	......	13	......	......	......	......	0	2	0	......	......	......	0	0	0
E5	Grass	......	......	0	......	......	......	0	......	5	......	4	......	6	......	......	0	......	0	......	1	......	......	......	5	......	1	......	16	......	......	......	......	......	7	......
	0 - 1.5	......	......	1	......	......	......	7	......	0	......	0	1	0	......	......	5	1	3	......	0	......	......	......	0	......	0	......	1	......	......	......	......	......	0	......
E6	Grass	0	......	0	......	0	......	0	......	1	......	1	......	4	......	0	0	......	0	......	0	......	8	......	0	......	0	......	0	......	0	......	0	......	0	......
	0 - 1.5	3	42	2	26	4	10	472	22	10	30	51	99	36	2	15	44	......	5	2	2	......	49	16	4	3	37	56	40	20	9	9	25	14	5	4
	1.5 - 5	5	2	1	6	0	0	11	0	0	1	35	15	0	7	2	15	......	0	6	2	......	2	16	1	1	0	0	5	0	0	0	4	8	0	0
	5 - 8.5	0	6	0	1	2	0	0	0	0	0	0	0	9	3	5	3	......	0	0	0	......	0	0	0	0	0	0	6	0	1	0	1	1	0	0
E7	Grass	......	......	0	......	1	......	3	......	2	......	4	......	14	......	2	0	......	5	......	1	......	13	......	4	......	1	......	9	......	......	......	0	......	......	......
	0 - 1.5	......	5	2	4	3	......	3	1	13	3	6	1	12	......	4	1	2	9	......	3	......	1	......	0	3	1	4	7	......	......	......	8	2	......	2
	1.5 - 5	......	0	0	0	0	......	0	0	0	0	0	0	0	......	0	0	0	0	......	0	......	0	......	0	0	0	0	0	......	......	......	1	0	......	0
E8	Grass	2	......	0	......	1	......	3	......	2	......	1	......	22	......	2	0	......	0	......	1	......	0	......	25	......	18	......	4	......	8	......	0	......	9	......
	0 - 1.5	5	22	2	99	0	......	15	23	8	9	2	14	19	......	2	2	17	6	0	0	5	0	1	6	12	256	7	8	2	45	218	15	58	38	38
	1.5 - 5	10	1	1	12	0	......	22	0	0	0	7	2	0	......	0	0	0	0	4	0	0	0	19	0	1	3	1	1	5	11	0	14	7	8	91
	5 - 8.5	11	0	24	0	1	......	16	0	0	0	0	3	53	......	4	73	0	0	0	0	8	89	0	12	2	0	0	0	0	2	0	0	0	12	61
E9	Grass	......	......	......	......	......	......	0	......	0	......	......	......	0	......	0	0	......	2	......	1	......	0	......	0	......	1	......	0	......	0	......	......	......	0	......
	0 - 1.5	......	......	......	......	......	3	3	2	4	......	......	3	14	4	9	3	......	0	......	5	......	7	0	3	10	1	18	7	3	4	......	......	......	3	19
	1.5 - 5	......	......	......	......	......	0	0	0	0	......	......	0	0	7	0	0	......	0	......	0	......	0	9	0	4	0	0	0	0	0	......	......	......	0	0
	5 - 8.5	......	......	......	......	......	0	0	0	0	......	......	0	0	0	3	0	......	0	......	0	......	1	0	0	0	0	0	0	0	0	......	......	......	0	0

TABLE I (Cont.)

The Numbers of All Species of Microarthropods Recorded by Sample, Season, and Depth for the Grass and Upper 8.5 Inches of Soil

For locations of samples, see text (Methods) and Figure 3.

ORGANISM	Depth (inches)	Sept. 22		Oct. 20		Oct. 27		Nov. 3		Nov. 17		Dec. 15		Jan. 5		Jan.19	Feb. 18		March 18		March 25		Apr. 8		Apr. 15		May 6		May 27		June 10		July 15		Sept. 2	
		B4 1450	D3 2515	D1 0623	E5 3939	*J1 4426	*E5 2242	L4 3616	M5 1142	K3 6010	M2 1020	H7 4526	F2 2932	J8 1142	M6 1251	O5 2841	H5 4022	*C2 0711	*E3 1519	*E2 5854	*C6 1139	*Q7 4658	B6 1410	*N3 1205	*P7 585"	K8 2213	B6 1143	*I2 2607	J5 4616	I9 4628	N7 3742	*Q8 2507	N9 6018	N2 0310	K3 0335	G8 4853
Acarina (Cont.) E10	Grass	......	......	......	......	......	......	1	......	1	......	......	......	......	......	......	......	......	......	......	5	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......
	0 - 1.5	......	......	......	......	......	......	1	......	1	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	0	......
E11	Grass	0	......	0	......	......	......	0	......	0	......	2	......	0	......	4	0	......	0	......	4	......	0	......	4	......	4	......	4	......	0	......	0	......	1	......
	0 - 1.5	25	3	4	8	......	......	30	2	4	8	3	3	68	9	16	21	16	3	5	0	19	2	1	0	5	35	4	18	14	22	23	22	15	5	26
	1.5 - 5	2	0	0	0	......	......	0	0	0	0	0	11	1	3	0	1	0	0	0	0	0	0	1	1	0	6	0	2	0	0	1	0	0	0	0
	5 - 8.5	0	0	0	0	......	......	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
E12	Grass	......	......	0	......	......	......	0	......	2	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......
	0 - 1.5	......	......	3	......	......	......	1	......	1	......	......	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......
E13	Grass	7	......	5	......	81	......	39	......	27	......	307	......	18	......	60	4	......	32	......	74	......	27	......	70	......	17	......	29	......	2	......	0	......	1	......
	0 - 1.5	6	32	26	4	9	......	374	34	0	10	0	28	5	2	1	34	19	16	......	4	......	10	......	0	19	6	31	15	3	42	11	3	25	2	38
	1.5 - 5	0	0	0	0	0	......	0	0	0	0	0	0	0	0	0	0	0	0	......	0	......	0	......	0	0	0	0	0	0	0	0	0	0	0	0
	5 - 8.5	0	1	0	0	0	......	0	0	0	0	0	0	0	0	0	0	0	0	......	0	......	0	......	0	0	0	0	0	0	0	0	0	0	0	0
E16	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	2	......	......	......	......	......	......	......	......	......	......	......
E18	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......
	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	4	......	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	......
E19	0 - 1.5	......	5	......	......	......	......	......	......	......	......	......	......	......	......	......	1	4	......	......	......	2	......	......	......	......	......	......	......	......	......	......	......	......	......	......
E21	Grass	......	......	0	......	......	......	0	......	......	......	0	......	......	......	0	0	......	......	......	......	......	0	......	......	......	0	......	1	......	1	......	0	......	0	......
	0 - 1.5	......	4	0	......	......	......	1	3	......	......	1	0	......	......	0	1	......	......	0	......	0	0	0	......	......	0	......	6	1	0	18	26	10	11	12
	1.5 - 5	......	1	0	......	......	......	2	0	......	......	4	1	......	......	0	2	......	......	2	......	2	0	13	......	......	2	......	0	0	0	0	20	77	3	1
	5 - 8.5	......	4	1	......	......	......	0	10	......	......	0	0	......	......	3	1	......	......	0	......	5	1	0	......	......	0	......	0	0	0	0	0	0	0	2
E22	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	1.5 - 5	......	......	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	5 - 8.5	......	......	......	......	......	......	......	......	......	......	......	......	3	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
E24	0 - 1.5	......	......	......	......	......	......	45	16	......	13	......	......	......	16	......	3	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
E25	Grass	0	......	......	......	0	......	......	......	......	......	2	......	......	......	0	0	......	......	......	......	......	0	......	......	......	0	......	......	......	1	......	......	......	0	......
	0 - 1.5	1	9	......	6	2	......	......	......	......	......	0	98	......	......	5	10	5	......	31	......	......	6	......	......	2	1	12	......	......	5	......	......	84	10	......
E26	Grass	......	......	......	......	......	......	15	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	1	......	2	......	......	......	......	......
E27	0 - 1.5	......	1	1	2	2	......	1	......	......	......	0	......	......	0	......	......	......	......	......	......	......	1	......	......	......	7	1	1	14	......	......	3	......	10	5
	1.5 - 5	......	0	0	0	0	......	2	......	......	......	0	......	......	1	......	......	......	......	......	......	......	0	......	......	......	0	0	0	2	......	......	0	......	0	0
	5 - 8.5	......	0	0	0	0	......	0	......	......	......	3	......	......	0	......	......	......	......	......	......	......	0	......	......	......	0	0	0	0	......	......	0	......	0	0
E28	0 - 1.5	......	24	......	......	17	......	......	1	......	......	0	......	......	0	......	......	......	2	0	......	......	......	......	......	......	7	......	6	2	......	2	6	16	......	1
	1.5 - 5	......	0	......	......	0	......	......	1	......	......	0	......	......	1	......	......	......	0	16	......	......	......	......	......	......	1	......	0	0	......	0	0	2	......	0
	5 - 8.5	......	0	......	......	0	......	......	0	......	......	2	......	......	0	......	......	......	0	0	......	......	......	......	......	......	0	......	0	0	......	0	0	0	......	0
E29	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......
E30	Grass	10	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	1	......
	0 - 1.5	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	......	0	1
E31	Grass	......	......	......	......	......	......	......	......	......	......	0	......	11	......	0	......	......	......	......	1	......	3	......	0	......	0	......	......	......	......	......	......	......	2	......
	0 - 1.5	......	......	......	11	......	46	......	1	......	......	0	......	38	0	85	......	1	......	0	0	......	0	......	1	2	6	1	......	......	......	......	......	......	0	......
	1.5 - 5	......	......	......	0	......	0	......	1	......	......	6	......	0	3	3	......	0	......	3	0	......	0	......	1	0	0	0	......	......	......	......	......	......	0	......
	5 - 8.5	......	......	......	0	......	0	......	0	......	......	0	......	0	1	2	......	0	......	0	0	......	0	......	0	2	0	0	......	......	......	......	......	......	0	......
E32	0 - 1.5	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	2	......	......	......
	1.5 - 5	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	0	......	......	......
	5 - 8.5	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	0	......	......	......
E33	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......
E34	0 - 1.5	......	......	......	......	......	......	0	......	......	......	......	0	......	0	......	......	......	......	......	......	......	3	......	......	......	......	......	......	......	......	......	......	......	1	......
	1.5 - 5	......	......	......	......	......	......	2	......	......	......	......	0	......	1	......	......	......	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	0	......
	5 - 8.5	......	......	......	......	......	......	2	......	......	......	......	1	......	0	......	......	......	......	......	......	......	5	......	......	......	......	......	......	......	......	......	......	......	0	......
E35	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	2	......	1	......	......	......	......	......	......	......
E36	0 - 1.5	......	......	......	6	......	......	1	......	......	......	......	......	......	......	......	1	......	......	......	......	0	51	0	......	......	6	......	......	......	......	......	......	......	......	......
	1.5 - 5	......	......	......	0	......	......	0	......	......	......	......	......	......	......	......	0	......	......	......	......	1	0	1	......	......	0	......	......	......	......	......	......	......	......	......
E37	Grass	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......
E38	0 - 1.5	......	......	2	1	......	......	5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	2	......	......	......	......	......	......	......	......	......	......	......	......
	1.5 - 5	......	......	0	1	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	6	......	......	......	......	......	......	......	......	......	......	......	......
E39	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......
E40	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	2	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
E41	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......

TABLE I (Cont.)

The Numbers of All Species of Microarthropods Recorded by Sample, Season, and Depth for the Grass and Upper 8.5 Inches of Soil

For locations of samples, see text (Methods) and Figure 3.

ORGANISM	Depth (inches)	Sept. 22		Oct. 20		Oct. 27		Nov. 3		Nov. 17		Dec. 15		Jan. 5		Jan.19	Feb. 18		March 18		March 25		Apr. 8		Apr. 15		[illegible]		[illegible]		June 10		July 15		[illegible]	
		B4	D3	D1	E5	*J1	*E5	L4	M5	K3	M2	H7	F2	J8	M6	O5	H5	*C2	*E3	*E2	[illegible]	*Q7	B6	*N3	*P7	K8	[illegible]	[illegible]	[illegible]	[illegible]	N7	*Q8	N9	N2	[illegible]	[illegible]
		1450	2515	0623	3939	4426	2242	3616	1142	6010	1020	4526	2932	1142	1251	2841	4022	0711	1519	5854	1139	4658	1410	1205	5857	2213	[illegible]	[illegible]	[illegible]	[illegible]	3742	2507	0618	0310	[illegible]	[illegible]
PAUROPODA 1	0 - 1.5	0	......	0	......	0	......	0	......	10	1	0	0	0	0	0	0	......	......	......	0	......	0	0	......	......	4	0	[illegible]	[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1.5 - 5	14	......	0	......	0	......	5	......	12	2	1	0	0	1	0	3	......	......	......	1	......	0	2	......	......	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14	[illegible]	[illegible]
	5 - 8.5	1	......	4	......	1	......	1	......	64	0	0	2	8	10	2	24	......	......	......	0	......	2	0	......	......	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6	[illegible]	[illegible]	[illegible]
2	1.5 - 5	3	......	......	......	......	......	1	......	1	......	......	0	0	1	......	0	......	......	......	......	0	......	......	0	......	0	......	......	......	......	......	[illegible]	[illegible]	[illegible]	[illegible]
	5 - 8.5	0	......	......	......	......	......	2	......	0	......	......	1	4	2	......	7	......	......	......	......	1	......	......	1	......	1	......	......	......	......	......	[illegible]	[illegible]	[illegible]	[illegible]
3	1.5 - 5	......	......	......	......	......	......	1	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
SYMPHYLA 1	0 - 1.5	......	2	0	......	0	......	......	1	0	......	......	0	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	0	1	......	......	[illegible]	......	4	[illegible]
	1.5 - 5	......	1	0	......	0	......	......	0	1	......	......	0	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	1	0	......	......	[illegible]	......	[illegible]	[illegible]
	5 - 8.5	......	1	1	......	1	......	......	0	2	......	......	1	......	2	......	......	......	......	......	......	......	......	......	......	......	......	......	0	0	......	......	[illegible]	......	[illegible]	[illegible]
HEXAPODA																																				
Protura 1	0 - 1.5	3	6	8	9	1	1	8	1	6	12	0	0	1	0	0	0	......	......	......	0	0	3	......	0	......	19	......	3	5	7	[illegible]	[illegible]	......	[illegible]	[illegible]
	1.5 - 5	3	2	0	1	0	0	1	0	13	2	5	0	0	0	0	0	......	......	......	2	2	0	......	0	......	4	......	0	0	[illegible]	[illegible]	1	......	[illegible]	6
	5 - 8.5	0	3	3	0	4	0	2	1	10	0	0	6	11	1	1	12	......	......	......	0	2	1	......	2	......	0	......	0	0	0	[illegible]	[illegible]	......	[illegible]	2
2	0 - 1.5	......	1	4	1	1	......	......	1	0	......	0	0	0	0	......	0	......	......	0	......	......	0	0	......	......	14	......	......	......	3	[illegible]	[illegible]	[illegible]	1	[illegible]
	1.5 - 5	......	0	0	0	0	......	......	0	1	......	0	0	0	1	......	0	......	......	0	......	......	0	1	......	......	0	......	......	......	0	[illegible]	[illegible]	[illegible]	[illegible]	1
	5 - 8.5	......	0	0	0	0	......	......	9	0	......	1	3	3	2	......	2	......	......	1	......	......	2	0	......	......	0	......	......	......	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	0 - 1.5	......	......	......	8	1	......	......	2	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	6	......	......	......	......	......	[illegible]	......	......	......
	1.5 - 5	......	......	......	0	0	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	......	[illegible]	......	......	......
	5 - 8.5	......	......	......	0	0	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	......	[illegible]	......	......	......
Thysanura Ectognatha 1	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	1	......	1	......	......	......	......
Entognatha Japygidae 1	0 - 1.5	0	......	0	0	0	0	0	......	0	0	0	0	0	0	0	0	......	......	......	......	0	0	0	0	0	2	......	6	4	28	[illegible]	[illegible]	[illegible]	1	1
	1.5 - 5	1	......	0	0	0	0	0	......	0	0	0	0	0	0	0	1	......	......	......	......	0	0	1	0	0	0	......	1	6	2	6	[illegible]	[illegible]	[illegible]	1
	5 - 8.5	3	......	7	1	4	1	3	......	5	7	2	2	13	4	4	0	......	......	......	......	1	2	0	4	1	0	......	0	1	0	1	[illegible]	1	1	1
Collembola P1	Grass	0	......	0	......	0	......	0	......	0	......	0	......	0	......	0	0	......	......	......	......	......	0	......	0	......	1	......	0	......	0	......	[illegible]	......	[illegible]	......
	0 - 1.5	0	1	3	0	0	......	0	0	0	1	2	0	4	0	0	5	......	......	0	......	0	0	0	0	......	127	42	38	57	78	1	25	[illegible]	[illegible]	79
	1.5 - 5	13	17	2	12	0	......	73	0	161	10	88	1	0	16	2	27	......	......	5	......	5	0	37	1	......	1	0	2	4	2	1	5	16	[illegible]	15
	5 - 8.5	20	13	204	1	12	......	13	12	175	0	0	103	44	10	52	87	......	......	0	......	10	15	0	14	......	0	0	4	0	1	0	17	5	42	12
P2	Grass	0	......	0	......	0	......	0	......	0	......	0	......	0	......	0	0	......	......	......	......	......	0	......	0	......	0	......	1	......	0	......	[illegible]	......	1	......
	0 - 1.5	0	3	1	0	0	......	1	0	0	0	1	0	1	0	0	0	......	......	0	......	0	3	0	0	......	8	5	23	3	10	1	3	5	[illegible]	19
	1.5 - 5	13	11	0	69	0	......	4	0	8	3	17	5	0	21	0	1	......	......	5	......	13	0	11	0	......	2	0	2	0	0	0	2	[illegible]	[illegible]	1
	5 - 8.5	1	15	8	0	2	......	2	1	24	0	0	16	39	11	8	23	......	......	0	......	7	8	0	1	......	0	0	0	0	0	0	[illegible]	[illegible]	4	0
P3	0 - 1.5	0	......	......	......	......	......	0	......	0	......	......	......	......	......	0	0	......	......	......	......	0	......	......	......	......	......	......	......	1	8	......	......	......	......	......
	1.5 - 5	6	......	......	......	......	......	0	......	3	......	......	......	......	......	0	1	......	......	......	......	0	......	......	......	......	......	......	......	0	0	......	......	......	......	......
	5 - 8.5	3	......	......	......	......	......	3	......	6	......	......	......	......	......	1	2	......	......	......	......	3	......	......	......	......	......	......	......	0	0	......	......	......	......	......
P4	Grass	0	......	0	......	0	......	1	......	4	......	0	......	1	......	0	0	......	......	......	6	......	......	......	2	......	......	......	0	......	......	......	......	......	......	......
	0 - 1.5	0	2	15	3	1	1	82	......	11	64	17	......	0	3	18	17	......	......	......	0	2	......	1	0	......	......	2	4	......	......	......	......	......	......	......
	1.5 - 5	0	2	0	0	0	0	0	......	0	1	0	......	0	0	0	0	......	......	......	0	0	......	0	0	......	......	0	0	......	......	......	......	......	......	......
	5 - 8.5	4	7	0	0	0	0	0	......	0	0	0	......	0	0	0	0	......	......	......	0	0	......	0	0	......	......	0	0	......	......	......	......	......	......	......
P5	Grass	0	......	......	......	......	......	0	......	0	......	0	......	0	......	0	0	......	0	......	......	......	0	......	1	......	0	......	0	......	0	......	......	......	0	......
	0 - 1.5	0	1	......	1	......	1	5	10	18	2	9	0	159	0	4	4	......	2	3	......	......	3	0	0	4	2	1	1	2	4	......	......	1	8	......
	1.5 - 5	1	1	......	1	......	0	1	0	0	1	8	44	0	3	1	4	......	1	6	......	......	7	4	0	0	0	1	0	0	0	......	......	0	0	......
	5 - 8.5	0	0	......	0	......	0	0	0	0	0	0	2	0	0	8	0	......	0	0	......	......	1	0	0	0	0	0	0	0	0	......	......	0	0	......
P7	0 - 1.5	......	......	......	......	......	......	......	1	......	......	1	......	9	......	1	6	......	......	......	......	......	......	1	......	1	......	......	1	......	1	......	......	......	......	......
P8	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	2	......	......	......	......	......	......	......
P9	0 - 1.5	0	2	......	0	......	......	2	......	......	1	0	0	1	......	0	1	......	......	0	......	......	......	0	......	5	10	......	4	1	7	......	1	......	14	[illegible]
	1.5 - 5	3	8	......	45	......	......	8	......	......	0	2	14	0	......	0	0	......	......	5	......	......	......	16	......	0	0	......	0	0	0	......	0	......	0	0
	5 - 8.5	0	2	......	0	......	......	0	......	......	0	0	1	5	......	11	0	......	......	0	......	......	......	0	......	0	0	......	0	0	0	......	0	......	0	0
P10	0 - 1.5	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
P11	0 - 1.5	......	......	......	......	......	3	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
P12	0 - 1.5	......	0	0	0	0	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	0	......	......	......	......	1	......	......	......	......	......	......	......	......	0
	1.5 - 5	......	0	0	2	0	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	2	......	......	......	......	0	......	......	......	......	......	......	......	......	2
	5 - 8.5	......	1	1	0	1	......	......	......	......	......	......	......	......	......	......	3	......	......	......	......	0	......	......	......	......	0	......	......	......	......	......	......	......	......	0
P13	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	2	......	......	......	......	......	......	7	......	......	......	......	......	......	......	......	......	......	......	......	......	......
E1	0 - 1.5	......	......	2	......	......	......	9	......	3	1	......	1	5	......	......	8	......	......	1	2	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......
E2	Grass	......	......	......	......	......	......	......	......	2	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	0 - 1.5	......	......	......	......	......	......	......	1	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......

TABLE I (Cont.)

The Numbers of All Species of Microarthropods Recorded by Sample, Season, and Depth for the Grass and Upper 8.5 Inches of Soil

For locations of samples, see text (Methods) and Figure 3.

ORGANISM	Depth (inches)	Sept. 22		Oct. 20		Oct. 27		Nov. 3		Nov. 17		Dec. 15		Jan. 5		Jan.19	Feb. 18		March 18		March 25		Apr. 8		Apr. 15		May 6		May 27		June 10		July 15		Sept. 2	
		B4 1450	D3 2515	D1 0623	E5 3939	*J1 4426	*E5 2242	L4 3616	M5 1142	K3 6010	M2 1020	H7 4526	F2 2932	J8 1142	M6 1251	05 2841	H5 4022	*C2 0711	*E3 1519	*E2 5854	*C6 1139	*Q7 4658	B6 1410	*N3 1205	*P7 5857	K8 2213	B6 1143	*I2 2607	J5 4616	I9 4628	N7 3742	*Q8 2507	N9 6018	N2 0310	K3 0335	G8 4853
Collembola (Cont.) E3	0 - 1.5	......	......	......	1	......	......	......	......	......	......	9	......	......	......	......	3	......	......	......	......	......	......	......	......	......	1	......	......	2	1	1	......	1	......	3
	1.5 - 5	......	......	......	0	......	......	......	......	......	......	2	......	......	......	......	0	......	......	......	......	......	......	......	......	......	0	......	......	0	0	0	......	0	......	0
	5 - 8.5	......	......	......	0	......	......	......	......	......	......	0	......	......	......	......	1	......	......	......	......	......	......	......	......	......	0	......	......	0	0	0	......	0	......	0
E4	0 - 1.5	......	......	......	......	......	1	......	......	......	......	......	2	14	......	......	6	......	......	......	......	......	......	0	......	1	......	......	......	1	......	......	......	1	......	......
	1.5 - 5	......	......	......	......	......	0	......	......	......	......	......	0	0	......	......	0	......	......	......	......	......	......	22	......	0	......	......	......	0	......	......	......	0	......	......
S1	0 - 1.5	......	3	2	2	......	......	1	......	......	......	......	......	......	......	......	5	......	......	......	11	1	10	......	1	......	3	......	......	......	......	......	......	......	......	......
	1.5 - 5	......	0	0	0	......	......	0	......	......	......	......	......	......	......	......	0	......	......	......	0	0	0	......	0	......	0	......	......	......	......	......	......	......	......	......
	5 - 8.5	......	1	0	0	......	......	0	......	......	......	......	......	......	......	......	0	......	......	......	0	0	0	......	0	......	0	......	......	......	......	......	......	......	......	......
S2	0 - 1.5	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
S3	0 - 1.5	......	......	......	......	......	......	0	......	......	2	......	......	......	......	......	13	......	......	......	6	......	......	......	......	......	1	3	......	3	......	......	......	......	......	2
	1.5 - 5	......	......	......	......	......	......	0	......	......	0	......	......	......	......	......	0	......	......	......	0	......	......	......	......	......	0	0	......	0	......	......	......	......	......	0
	5 - 8.5	......	......	......	......	......	......	1	......	......	0	......	......	......	......	......	0	......	......	......	0	......	......	......	......	......	0	0	......	0	......	......	......	......	......	0
S4	0 - 1.5	......	......	......	......	......	......	2	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Corrodentia P1	Grass	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	1	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
P2	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
P3	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	4	......	......	......
P4	0 - 1.5	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Thysanoptera 1	Grass	......	......	......	......	......	......	......	......	2	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
2	Grass	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	0	......	......	......
	0 - 1.5	......	......	......	......	......	......	......	1	0	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......
3	Grass	......	......	0	......	......	......	4	......	1	......	......	......	4	......	......	2	......	......	......	2	......	......	......	......	......	......	......	3	......	1	......	......	......	2	......
	0 - 1.5	......	......	0	......	......	......	0	......	0	......	......	......	0	1	......	1	......	......	......	0	......	......	0	......	......	......	......	0	......	0	......	......	......	0	......
	1.5 - 5	......	......	0	......	......	......	0	......	0	......	......	......	0	0	......	0	......	......	......	0	......	......	1	......	......	......	......	0	......	0	......	......	......	0	......
	5 - 8.5	......	......	2	......	......	......	0	......	0	......	......	......	0	0	......	0	......	......	......	0	......	......	0	......	......	......	......	0	......	0	......	......	......	0	......
4	Grass	......	......	2	......	......	......	6	......	2	......	......	......	......	......	4	0	......	......	......	3	......	1	......	2	......	1	......	......	......	3	......	......	......	1	......
	0 - 1.5	......	......	0	......	......	......	0	......	0	......	......	......	......	......	0	2	......	......	......	0	......	0	......	0	......	0	......	......	......	0	......	......	......	0	......
5	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
6	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	3	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	1.5 - 5	......	......	......	......	......	......	......	......	......	......	......	......	......	6	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
7	Grass	......	......	......	......	......	......	......	......	......	......	2	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	0	......	......	......
	0 - 1.5	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......
9	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	2	......	4	......	......	......	......	......	......	......	......	......	1	......	1	......	......	......
10	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
11	1.5 - 5	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
12	Grass	7	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
13	Grass	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
14	Grass	......	......	6	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	3	......	......	......	......	......	......	......
15	0 - 1.5	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Hemiptera (ad.) T1	Grass	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	2	......	1	......	......	......	......	......	......	......	0	......	......	......
	0 - 1.5	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	0	......	3	......	......	1	......	......	......	......	4	......	......	......
L1	Grass	0	......	......	......	......	......	0	......	0	......	......	......	......	......	......	......	......	......	......	1	......	......	......	2	......	......	......	......	......	......	......	......	......	......	......
	0 - 1.5	3	......	......	......	......	......	3	......	1	......	......	......	......	......	......	......	......	......	......	0	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......
(nymph) 1	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......
3	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......
Homoptera (ad.) Ce 1	Grass	......	......	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	0 - 1.5	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Ci 1	Grass	2	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	0	......	1	......	......	......	1	......	......	......
	0 - 1.5	0	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	0	......	......	......	0	......	......	......
Co 1	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......
(nymph) 1	Grass	......	......	6	......	1	......	10	......	......	......	22	......	4	......	3	......	......	0	......	......	......	7	......	1	......	2	......	2	......	1	......	......	......	2	......
	0 - 1.5	......	10	4	......	0	......	1	2	......	......	0	2	0	......	0	......	......	1	......	......	......	0	......	0	......	0	1	0	......	0	......	......	......	0	......
2	Grass	......	......	......	......	......	......	3	......	......	......	0	......	6	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	1	......	......	......	2	......
	0 - 1.5	......	......	......	......	......	......	0	......	......	......	1	......	0	1	......	......	1	......	......	......	......	......	......	0	......	......	......	......	......	0	......	......	......	0	......

TABLE I (Cont.)

The Numbers of All Species of Microarthropods Recorded by Sample, Season, and Depth for the Grass and Upper 8.5 Inches of Soil

For locations of samples, see text (Methods) and Figure 3.

ORGANISM		Depth (inches)	Sept. 22		Oct. 20		Oct. 27		Nov. 3		Nov. 17		Dec. 15		Jan. 5		Jan. 19	Feb. 18		March 18		March 25		Apr. 8		Apr. 15		May 6		May 27		June 10		July 15		Sept. 2	
			B4 1450	D3 2515	D1 0623	E5 3939	*J1 4426	*E5 2242	L4 3616	M5 1142	K3 6010	M2 1020	H7 4526	F2 2932	J8 1142	M6 1251	O5 2841	H5 4022	*C2 0711	*E3 1519	*E2 5854	*C6 1139	*Q7 4658	B8 1410	*N3 1205	*P7 5857	K8 2213	B6 1143	*I2 2607	J5 4616	I9 4628	N7 3742	*Q8 2507	N9 6018	N2 0310	K3 0335	G8 4853
Homoptera (nymph) (cont.)	3	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......
	4	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	8	......	......	......	......	......	1	......
	5	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	2	......	......	......	......	......	......	......
	6	Grass	......	......	0	......	......	......	1	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		0 - 1.5	......	......	1	......	......	......	0	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	7	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	8	Grass	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......
Coleoptera (ad.)	Ca 1	Grass	......	......	0	......	......	......	0	......	0	......	......	......	......	......	......	......	......	......	......	1	......	......	......	0	......	0	......	......	......	......	......	......	......	......	......
		0 - 1.5	......	......	1	......	......	......	1	......	2	......	......	......	......	......	......	......	1	......	......	1	......	......	......	1	......	1	......	......	......	......	......	......	......	......	......
	St 1	0 - 1.5	......	......	......	1	......	......	1	......	......	1	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	St 2	Grass	......	......	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......
		0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......
	St 3	5 - 8.5	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	St 4	0 - 1.5	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	St 5	1.5 - 5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	El 1	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......
	Ci 1	Grass	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	Sc 1	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......
	Rh 1	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	Rh 2	Grass	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......
	U 1	Grass	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	0	......	......	......	1	......	......	......	......	......	......	......	1	......	......	......	......	......
		0 - 1.5	......	......	......	......	......	......	......	......	1	1	......	......	......	......	......	......	......	0	......	......	......	0	......	......	......	......	......	......	......	0	......	......	......	......	......
		1.5 - 5	......	......	......	......	......	......	......	......	0	0	......	......	......	......	......	......	......	1	......	......	......	0	......	......	......	......	......	......	......	0	......	......	......	......	......
	U 2	Grass	......	......	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......
		0 - 1.5	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......
(larva)	1	Grass	......	......	0	......	0	......	......	......	2	......	......	......	0	......	......	......	......	......	......	2	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		0 - 1.5	......	......	1	......	2	......	......	3	1	......	......	......	1	......	......	......	......	......	......	0	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	2	Grass	......	......	0	......	0	......	1	......	0	......	......	......	......	......	......	......	......	......	......	......	......	0	......	......	......	1	......	0	......	......	......	......	......	......	......
		0 - 1.5	......	......	2	2	1	1	1	1	2	1	......	1	......	1	......	......	......	......	0	......	......	1	......	......	......	0	......	1	......	......	......	......	......	......	......
		1.5 - 5	......	......	0	0	0	0	0	0	0	0	......	0	......	0	......	......	......	......	1	......	......	0	......	......	......	0	......	0	......	......	......	......	......	......	......
	3	0 - 1.5	......	......	......	......	......	......	......	......	2	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	5	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	6	Grass	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	7	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	1	1	......	......
		1.5 - 5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	0	0	......	......
	8	0 - 1.5	......	......	......	2	......	......	......	2	......	......	......	......	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	......	......	......	......	......	0	......	1
		1.5 - 5	......	......	......	0	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	1	......	0
	9	0 - 1.5	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	10	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	4	......	......	......	......	......	......	......
	11	Grass	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......
		0 - 1.5	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	......	......	......
	12	0 - 1.5	......	......	1	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	......	......	......	......	1
		1.5 - 5	......	......	0	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	1
	13	Grass	......	......	0	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......
		0 - 1.5	......	......	1	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	1
	14	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Lepidoptera (larva)	1	Grass	......	......	......	......	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......
		0 - 1.5	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	......	......	......	......	......	0	......	......	......	......	......

TABLE I (Cont.)

The Numbers of All Species of Microarthropods Recorded by Sample, Season, and Depth for the Grass and Upper 8.5 Inches of Soil

For locations of samples, see text (Methods) and Figure 3

ORGANISM	Depth (inches)	Sept. 22		Oct. 20		Oct. 27		Nov. 3		Nov. 17		Dec. 15		Jan. 5		Jan.19	Feb. 18		March 18		March 25		Apr. 8		Apr. 15		May 6		May 27		June 10		July 15		Sept. 2	
		B4 1450	D3 2515	D1 0623	E5 3939	*J1 4426	*E5 2242	L4 3616	M5 1142	K3 6010	M2 1020	H7 4526	F2 2932	J8 1142	M6 1251	O5 2841	H5 4022	*C2 0711	*E3 1519	*E2 5854	*C6 1139	*Q7 4658	B6 1410	*N3 1205	*P7 5857	K8 2213	B6 1143	*I2 2607	J5 4616	I9 4628	N7 3742	*Q8 2507	N9 6018	N2 0310	K3 0335	G8 4853
Lepidoptera (larva) (Cont.) 2	Grass	......	......	......	......	......	......	0	......	1	......	2	......	0	......	......	......	......	......	......	3	......	......	......	......	......	0	......	2	......	......	......	......	......	......	......
	0 - 1.5	......	1	......	......	......	......	1	......	0	......	0	2	1	......	......	......	......	......	1	1	......	......	......	......	......	1	......	0	......	......	......	......	......	......	......
3	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
7	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
8	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	1	......	......	......	......
Diptera (ad.) P1	0 - 1.5	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
F1	0 - 1.5	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
(larva) T1	0 - 1.5	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
U1	Grass	1	......	......	......	......	......	......	......	0	......	......	......	4	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	0 - 1.5	0	1	......	......	......	0	......	......	1	......	......	......	0	1	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	1.5 - 5	0	0	......	......	......	1	......	......	0	......	......	......	0	0	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
U2	Grass	......	......	......	......	......	......	......	......	3	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	3	......	......	......	......	......	......	......
	0 - 1.5	......	......	......	......	......	......	......	......	0	......	......	2	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	......	......	......
U3	Grass	......	......	......	......	......	......	......	......	2	......	10	......	......	......	3	......	......	......	......	5	......	13	......	......	......	......	......	1	......	......	......	......	......	1	......
	0 - 1.5	......	......	......	......	......	......	......	......	0	1	1	......	......	......	0	......	......	......	......	0	......	0	......	......	......	......	......	0	......	......	......	......	......	0	......
U4	Grass	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	0	......	......	......	0	......	......	......	......	......	0	......	1	......
	0 - 1.5	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	3	......	......	1	......	......	1	......	0	......
U5	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......
U6	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1
U7	0 - 1.5	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
U8	Grass	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......
	0 - 1.5	......	......	4	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	2	0	......	......	......	......	......	......	......	......	......	......	......	......	......
U9	5 - 8.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......
U10	1.5 - 5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Hymenoptera C1	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
C3	0 - 1.5	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
C4	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
C5	Grass	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
C6	0 - 1.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......
C7	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......
C8	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......
C9	Grass	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
F1	Grass	......	......	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	......	2	......	0	......	......	......
	0 - 1.5	......	......	......	......	......	......	......	0	......	......	......	......	0	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	3	0	......	1	......	......	......
	1.5 - 5	......	......	......	......	......	......	......	2	......	......	......	......	6	......	......	......	......	0	......	......	......	......	......	......	......	......	......	......	0	0	......	0	......	......	......
	5 - 8.5	......	......	......	......	......	......	......	0	......	......	......	......	0	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	0	0	......	0	......	......	......
F2	Grass	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	2	......	......	......	0	......	......	......
	0 - 1.5	......	9	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	0	......	......	......	......	......	......	......	......	0	......	......	......	1	......	......	......
	1.5 - 5	......	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	4	......	......	......	......	......	......	......	......	0	......	......	......	0	......	......	......
F3	0 - 1.5	......	......	5	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	1.5 - 5	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	2	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	5 - 8.5	......	......	0	......	......	......	......	......	......	......	......	......	......	......	......	112	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......

TABLE II

Seasonal and Vertical Distribution of Microarthropods in Four Samples Taken to the Full Depth of the Soil

ORGANISM	Depth (inches)	Nov. 17 K3 6010	Feb. 11 K3 3021	Apr. 22 K4 4556	Aug. 12 K3 1722
ARACHNIDA					
Phalangida 1	Grass	1	......	......	......
Araneida 1	Grass	......	......	......	2
	0 - 1.5	......	......	......	1
2	Grass	......	......	......	1
Acarina P1	Grass	2	0	0	1
	0 - 1.5	18	8	0	2
	1.5 - 5	330	50	0	273
	5 - 8.5	70	35	0	95
	8.5 - 12	13	5	0	13
	12 - 16	1	6	1	0
	16 - 20	3	0	0	0
	20 - 24	17	0	0	0
	24 - 28	12	0	0	0
P2	Grass	5	0	......	1
	0 - 1.5	19	1	......	5
	1.5 - 5	0	0	....	3
P3	Grass	0	1	......	......
	0 - 1.5	4	3	......	......
P4	Grass	12	[illegible]	4	2
	0 - 1.5	9	1	1	4
P5	Grass	6	0	5	12
	0 - 1.5	9	16	0	9
P8	0 - 1.5	......	......	......	3
	1.5 - 5	......	......	......	1
O1	Grass	3	0	34	23
	0 - 1.5	68	12	51	157
	1.5 - 5	264	77	0	333
	5 - 8.5	402	328	0	28
	8.5 - 12	199	549	0	123
	12 - 16	1	186	71	50
	16 - 20	114	285	0	0
	20 - 24	95	0	1	4
	24 - 28	43	1	0	0
	28 - 32	8	13	3	0
	32 - 36	0	6	0	0
O2	Grass	0	0	11	5
	0 - 1.5	40	25	0	5
	1.5 - 5	77	11	0	33
	5 - 8.5	152	46	0	14
	8.5 - 12	114	25	0	19
	12 - 16	0	27	66	7
	16 - 20	12	28	0	0
	20 - 24	17	0	0	0
	32 - 36	0	1	0	0
O3	Grass	2	0	5	11
	0 - 1.5	38	25	1	3
	1.5 - 5	7	0	0	0
	5 - 8.5	0	22	0	0
O4	Grass	5	12	10	4
	0 - 1.5	40	21	11	15
O5	Grass	0	0	0	2
	0 - 1.5	0	154	3	74
	1.5 - 5	5	21	0	68
	5 - 8.5	152	31	0	0
	8.5 - 12	4	2	0	2
	12 - 16	0	0	0	2
	16 - 20	15	0	0	0
	20 - 24	15	0	0	0
	24 - 28	3	0	0	0
O6	Grass	26	0	4	1
	0 - 1.5	344	98	5	2
O7	Grass	5	4	1	2
	0 - 1.5	3	4	0	0
Acarina (Cont.) O8	Grass	47	10	2	3
	0 - 1.5	58	4	0	0
	1.5 - 5	0	4	0	0
	5 - 8.5	0	28	0	0
O9	Grass	50	48	57	24
	0 - 1.5	0	19	24	30
	1.5 - 5	0	1	0	0
	5 - 8.5	0	0	0	0
	8.5 - 12	0	0	0	1
O10	0 - 1.5	......	5	......	......
O11	Grass	......	1	......	......
	0 - 1.5	......	3	......	......
O12	Grass	......	0	......	7
	0 - 1.5	......	1	......	9
O13	0 - 1.5	......	1	....	......
O14	Grass	1	1	2	10
	0 - 1.5	0	0	0	2
O15	Grass	......	1	......	......
O16	Grass	......	......	......	11
	0 - 1.5	......	......	......	3
	1.5 - 5	......	......	......	4
O17	0 - 1.5	......	......	......	1
O18	0 - 1.5	......	......	......	1
O19	0 - 1.5	......	......	......	1
S1	Grass	0	3	1	21
	0 - 1.5	123	51	0	5
	1.5 - 5	191	32	0	20
	5 - 8.5	32	74	0	2
	8.5 - 12	10	11	0	0
	12 - 16	0	62	0	0
	16 - 20	0	17	0	0
S2	5 - 8.5	......	1	......	......
T1	Grass	4	0	2	6
	0 - 1.5	58	31	0	6
T2	Grass	1	......	......	......
T3	0 - 1.5	......	......	......	1
T4	0 - 1.5	......	......	......	1
T7	Grass	......	15	20	6
	0 - 1.5	......	1	0	0
	1.5 - 5	......	0	0	2
T10	Grass	1	......	......	......
E1	Grass	3	1	5	0
	0 - 1.5	31	3	8	19
	1.5 - 5	21	9	1	89
	5 - 8.5	262	109	0	3
	8.5 - 12	338	79	2	8
	12 - 16	11	73	31	8
	16 - 20	100	52	1	0
	20 - 24	471	11	2	0
	24 - 28	389	1	1	0
	28 - 32	76	11	3	0
	32 - 36	......	7	1	1
	36 - 39	......	0	1	0
E2	0 - 1.5	53	2	......	1
	1.5 - 5	11	1	......	0
	5 - 8.5	21	3	......	0
	8.5 - 12	0	1	......	0
E3	Grass	30	5	13	12
	0 - 1.5	1954	77	0	1
	1.5 - 5	10	80	0	7
Acarina (Cont.) E4	Grass	5	0	......	......
	0 - 1.5	61	0	......	......
	1.5 - 5	6	3	......	......
	5 - 8.5	28	0	......	......
	8.5 - 12	11	0	......	......
	12 - 16	0	1	......	......
	16 - 20	1	0	......	......
E5	Grass	5	1	0	8
	0 - 1.5	0	0	1	0
E6	Grass	1	0	1	0
	0 - 1.5	10	16	3	9
	1.5 - 5	0	9	0	1
	5 - 8.5	0	4	0	1
	8.5 - 12	0	5	0	1
	12 - 16	0	0	0	1
E7	Grass	2	5	6	14
	0 - 1.5	13	1	0	15
E8	Grass	2	1	......	4
	0 - 1.5	8	1	......	2
	1.5 - 5	0	13	......	39
	5 - 8.5	0	31	......	0
	8.5 - 12	0	54	......	0
E9	0 - 1.5	0	5	......	......
	1.5 - 5	4	2	......	......
E10	Grass	1	......	......	......
	0 - 1.5	1	......	......	......
E11	Grass	0	0	10	4
	0 - 1.5	4	1	3	7
	1.5 - 5	0	0	0	0
	5 - 8.5	2	0	0	0
E12	Grass	2	......	......	......
	0 - 1.5	1	......	......	......
E13	Grass	27	7	26	84
	0 - 1.5	0	1	0	12
E16	Grass	......	......	26	------
E17	5 - 8.5	......	1	......	......
E18	0 - 1.5	......	1	....	......
E19	Grass	......	......	......	7
	0 - 1.5	......	......	......	2
E20	Grass	......	......	......	2
E21	0 - 1.5	......	......	......	6
E22	0 - 1.5	......	......	......	2
PAUROPODA 1	0 - 1.5	10	0	0	0
	1.5 - 5	12	0	0	15
	5 - 8.5	64	6	0	0
	8.5 - 12	5	4	1	11
	12 - 16	0	4	13	6
	16 - 20	5	1	0	0
	20 - 24	8	0	1	0
	24 - 28	15	0	0	0
	28 - 32	0	6	0	0
	32 - 36	0	5	0	0
2	1.5 - 5	1	0	......	3
	5 - 8.5	0	7	......	0
	28 - 32	0	2	......	0
3	1.5 - 5	1	0	......	0
	5 - 8.5	0	0	......	0
	8.5 - 12	0	2	......	1
	12 - 16	0	0	....	2
	16 - 20	0	1	......	0
	20 - 24	0	1	......	0
SYMPHYLA 1	1.5 - 5	1	0	......	[illegible]
	5 - 8.5	2	1	......	0
	8.5 - 12	6	1	......	1
	12 - 16	0	0	......	1
	16 - 20	2	0	......	0
HEXAPODA					
Protura 1	0 - 1.5	6	0	......	0
	1.5 - 5	13	2	......	6
	5 - 8.5	10	10	......	0
	8.5 - 12	17	3	......	0
	12 - 16	0	4	......	0
	16 - 20	1	2	......	0
	20 - 24	1	0	......	0
2	0 - 1.5	0	0	2	......
	1.5 - 5	1	0	0	......
	5 - 8.5	0	0	0	......
	8.5 - 12	0	1	0	......
Thysanura J1	0 - 1.5	0	0	0	1
	1.5 - 5	0	0	0	14
	5 - 8.5	5	0	0	1
	8.5 - 12	10	4	0	0
	12 - 16	3	7	2	0
	16 - 20	27	8	0	0
	20 - 24	7	2	4	1
	24 - 28	7	2	0	0
	28 - 32	1	6	0	0
Collembola P1	0 - 1.5	0	0	0	3
	1.5 - 5	161	48	0	6
	5 - 8.5	175	52	0	0
	8.5 - 12	35	12	0	0
	12 - 16	0	4	1	2
	16 - 20	14	2	0	0
	20 - 24	123	0	0	0
	24 - 28	124	0	0	0
	28 - 32	41	9	2	0
	32 - 36	......	18	0	0
	36 - 39	......	2	0	0
	39 - 42	......	4	0	0
P2	1.5 - 5	8	[illegible]	......	3
	5 - 8.5	24	39	......	0
	8.5 - 12	12	2	......	0
	12 - 16	0	1	......	0
	16 - 20	7	0	......	0
	20 - 24	7	0	......	0
P3	1.5 - 5	3	......	......	......
	5 - 8.5	6	......	......	......
	8.5 - 12	1	......	......	......
	12 - 16	0	......	......	......
	16 - 20	[illegible]	......	......	......
	20 - 24	1	......	......	......
P4	Grass	4	0	......	......
	0 - 1.5	11	1	......	......
P5	0 - 1.5	0	8	1	......
	1.5 - 5	18	2	0	......
P6	0 - 1.5	......	1	......	......
P7	0 - 1.5	......	......	......	4
P8	0 - 1.5	......	......	......	2
E1	0 - 1.5	3	1	......	......
E2	Grass	2	......	......	1
	0 - 1.5	1	......	......	0
Corrodentia					
P1	1.5 - 5	......	1	......	......
	28 - 32	1	......	......	......
Thysanoptera					
1	Grass	2	1	......	......
2	Grass	1	......	......	......
3	Grass	1	......	5	......
4	Grass	2	......	4	....
5	Grass	......	......	1	......
6	1.5 - 5	......	......	......	2
7	Grass	......	......	......	2
	0 - 1.5	......	......	......	1
Hemiptera					
(ad.) Re1	Grass	......	......	4	......
Re2	Grass	......	......	2	......
Ti1	Grass	......	......	1	1
L1	Grass	0	1	......	......
	0 - 1.5	1	0	......	......
(nymph) 1	Grass	......	1	......	......
2	Grass	......	......	......	1
Homoptera					
(nymph) 1	Grass	......	......	1	1
Coleoptera					
(ad.) Ca1	Grass	0	0	......	1
	0 - 1.5	2	1	......	0
St1	Grass	......	......	1	......
Rh1	Grass	......	1	......	1
U1	Grass	1	1	2	......
	0 - 1.5	1	0	0	......
(larva) 1	Grass	2	......	......	......
	0 - 1.5	1	......	......	......
2	0 - 1.5	2	......	......	......
3	0 - 1.5	2	......	......	......
4	0 - 1.5	......	......	......	1
Lepidoptera					
(larva) 1	0 - 1.5	1	......	......	......
2	Grass	1	1	......	......
3	Grass	......	......	1	......
4	0 - 1.5	......	......	......	1
5	Grass	......	......	......	2
Diptera					
(larva) 1	Grass	0	1	......	1
	0 - 1.5	1	1	......	0
2	Grass	3	......	......	......
3	Grass	2	1	4	......
Hymenoptera					
C1	Grass	......	......	1	......
C2	Grass	......	......	......	1
F1	5 - 8.5	......	1	......	......

that they were close to the eastern edge of the sampling area or to one of the two hickory trees on the field. Our next problem was to determine which samples represented chance variations and which fell outside such variations. Although discrepancies from seasonal trends had led us to postulate the existence of two kinds of samples, seasonal fluctuations observed for many species made the presence or absence of species more meaningful than numerical discrepancies in locating aberrant samples. The most ubiquitous species, then, should provide a stricter criterion than the most numerous ones for distinguishing between samples.

A frequency diagram (Fig. 2) of the species extracted from the soil

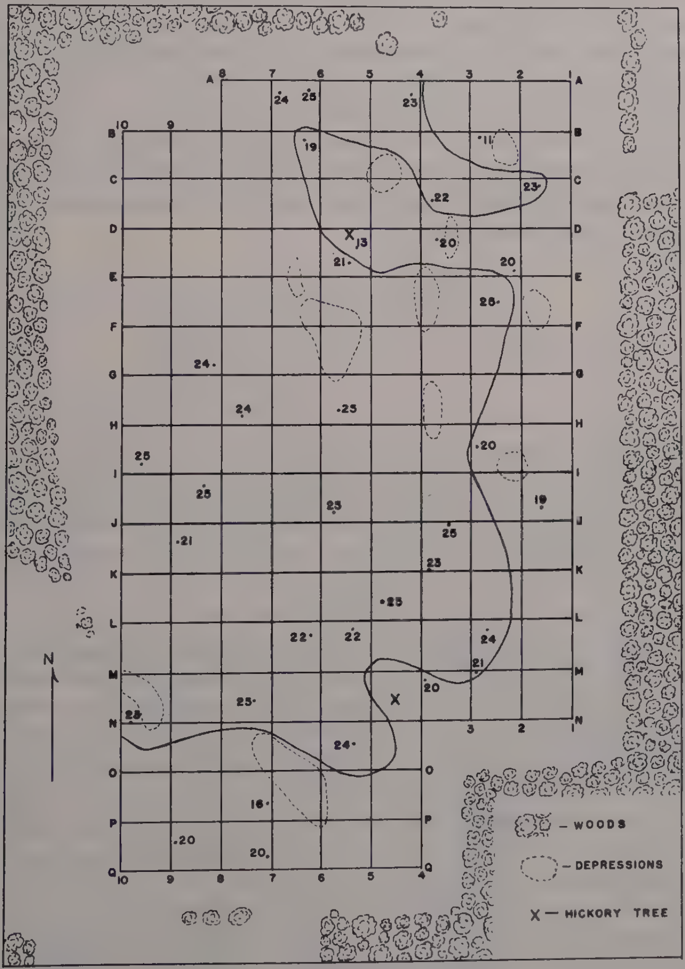

Fig. 3. Locations of 35 samples in the field and the observed number of occurrences of 25 common species in each. Grid positions are 60 feet apart.

shows an increase in numbers of species at high frequencies as compared with the number of slightly less frequent species, a situation typical of results of this kind of analysis. It will be noted that the curve begins to turn up at a frequency of about 25 samples and that there are 25 species, each of which is found in 25 or more of the 35 samples. Aside from chance absences, failures of these 25 species to appear in any sample should make one suspect that the sample came from a different kind of situation. Figure 3 is a map of the field giving the location of each sample and the number of species present from among these 25 which are most ubiquitous. It is obvious that a low number is related to the eastern and southern sides of the field and to the two large hickory trees standing on it. The line separates samples with 21 or more of the 25 species from those with 20 or fewer. It is evident, moreover, that lines separating the samples at other intervals will be nearly parallel to the line shown and also close to it. The line does divide the field into two areas; we may now consider the statistical validity of drawing it.

Among the 35 randomly collected samples there is a total of 111 failures of occurrence of one or another of the 25 species. Given this information, it is easy to calculate the expected chance distribution of absences among samples. The formulae for the successive terms of the binomial distribution are:

$$F_0 = X(\frac{X-1}{X})N; \quad F_1 = F_0 (N) (\frac{1}{X-1});$$

$$F_2 = F_1(\frac{N-1}{2}) (\frac{1}{X-1}); \quad F_3 = F_2(\frac{N-2}{3}) (\frac{1}{X-1}); \quad \text{etc.}$$

F is the number of samples expected to have 0, 1, 2, 3, and so forth, absences; N is the total number of absences; and X is the number of samples. The results are given in Table III and Figure 4, along with the observed distributions. The same method could be used for the 764

TABLE III

Comparison of Observed and Expected Frequencies of 25 Species of Microarthropods in 35 Randomly Collected Samples

Species Present	Species Absent	Expected Samples	Observed Samples	d	d^2	d^2/e
25	0	1.44267	9			
24	1	4.66746	5			
		6.11013	14	7.88987	62.25005	10.18801
23	2	7.48166	4	3.48166	12.12196	1.62022
22	3	7.92173	3	4.92173	24.22343	3.05785
21	4	6.23250	3	3.23250	10.44906	1.67654
20	5	3.88615	6	2.11385	4.46836	1.14982
19 or fewer	6 or more	3.36783	5	1.63217	2.66398	0.79101

d.f.: 5 chi-square: 18.48345

observed occurrences of the 25 species in the 35 samples, but the arithmetic would be more cumbersome and would yield only a mirror image of the curve obtained; we have thus equated 0 absences with 25 occurrences, 1 absence with 24 occurrences, and so forth, in Table III. There are more samples with all 25 species and more with 20 or fewer species than would be expected. When a test by chi-square at the 99 per cent confidence level is made, the probability that the observed distribution depends on chance is less than 0.003. The 99 per cent confidence limit is obtained by lumping the ends of the "expected" curve until the first expected number exceeds 2.0. The statistical test shows it to be highly improbable that the 35 samples all belong to the same group; the bimodal nature of the "observed" curve in Figure 4 confirms the foregoing suggestion that we are dealing with two kinds of samples.

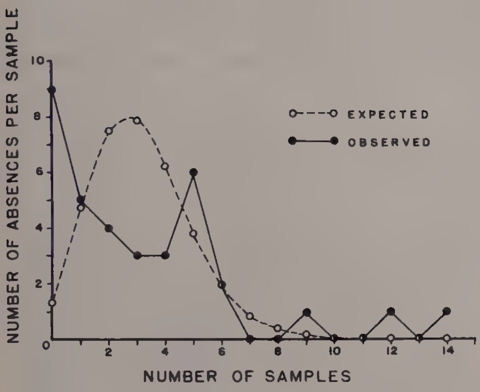

Fig. 4. Observed distribution of absences of 25 common species among 35 samples, compared with the expected chance distribution.

If the 24 samples containing 21 or more of the species are considered as a group and tested statistically in the same manner, they seem to be alike in the occurrences of the 25 species, subject to chance variations (chi-square is 4.98, with 3 degrees of freedom). The other 11 samples are distinctly different and must be discarded in considering seasonal fluctuations, vertical distribution, and mathematical relations between the numbers of species and individuals.

In spite of initial attempts to avoid the effects of the surrounding forest, the foregoing analysis indicates that we had not done so. The failure, however, seems to us to give evidence concerning the delicacy of balance of community organization. There is a large area in the center of the field where conditions are such that all of the 25 most ubiquitous species are extremely likely to occur. This area gives way abruptly to a peripheral one (not obviously different to the human observer) where conditions are such that five or more of these species are likely to be absent. We can envision only one or two factors that could produce this sharp division of the field into two areas: the effect of the shadow line of the trees at some critical season, or possibly the effect of widely spread tree roots in removing something critical from the soil. The curious feature is the absence of an obvious floristic division corresponding to this faunistic division.

One point concerning the observed division of the field that will have occurred to the critical reader is the effect of seasons upon the numerical abundance, and hence ultimately upon presence or absence, of these 25 species. In other words, are the seasons equally well represented on both sides of the line drawn in Figure 4, or is there an accidental correlation between season and distribution? To answer the question, the year was divided into four equal parts between solstices and equinoxes, and the sets of samples inside and outside the line were tested against the total distribution by means of chi-square. The results are given in Table IV. The seasonal variations in distribution of samples

TABLE IV

Comparison of the Proportions by Seasons of Samples Otherwise Classified According to the Presence or Absence of 25 Species of Soil Arthropods

Season	Total Samples	Number Inside Line	Number Outside Line					
	(P_i)		(x_i)	$\bar{p}P_i$	$x_i-\bar{p}P_i$	$(x_i-\bar{p}P_i)^2$	$\bar{p}\bar{q}P_i$	$\frac{(x_i-\bar{p}P_i)^2}{\bar{p}\bar{q}P_i}$
Fall	12	10	2	3.7716	-1.7716	3.1386	2.5862	1.2136
Winter	7	4	3	2.2001	0.7999	0.6398	1.5086	0.4241
Spring	12	6	6	3.7716	2.2284	4.9658	2.5862	1.9201
Summer	4	4	0	1.2572	-1.2572	1.5805	0.8621	1.8333

chi-square: 5.3911

$\bar{p} = 11/35$ 0.3143; $\bar{q} = 1 - \bar{p}$ d.f.:3 $0.1 < p < 0.2$

TABLE V

Comparison of the Proportions by Seasons as in Table IV

Here the seasons are of unequal length and each has approximately the same number of samples.

Dates	Total Samples	Number Inside Line	Number Outside Line					
	(P_i)		(x_i)	$\bar{p}P_i$	$x_i-\bar{p}P_i$	$(x_i-\bar{p}P_i)^2$	$\bar{p}\bar{q}P_i$	$\frac{(x_i-\bar{p}P_i)^2}{\bar{p}\bar{q}P_i}$
Sept. 22-Nov. 17	10	8	2	3.1428	-1.1428	1.3060	2.1550	0.6060
Dec. 15-March 18	9	6	3	2.8287	0.1713	0.0293	1.9396	0.0151
March 25-May 6	8	3	5	2.5144	2.4856	6.1782	1.7241	3.5834
May 27-Sept. 2	8	7	1	2.5144	-1.5144	2.2934	1.7214	1.3302

chi-square: 5.5347

$\bar{p}$ and $\bar{q}$ same as for Table 4 d.f.:3 $0.1 < p < 0.2$

are not significantly different from chance. Table IV shows the most meaningful ecological division of the samples by season. It does concentrate them in fall and spring. Dividing the samples so that each time period, regardless of length, gets a nearly equal number does not alter the statistical result, as is demonstrated in Table V.

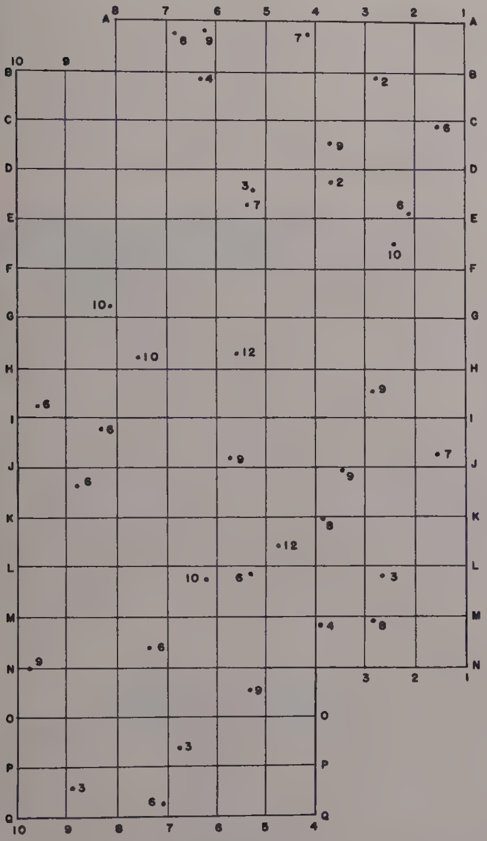

Fig. 5. Locations of 35 samples in the field and the observed number of occurrences of 14 less common species.

It thus seems justifiable to conclude that the field is divided rather sharply into two distinct areas as far as the 25 most ubiquitous species are concerned. What of the less frequent species? To return to Figure 2, there seems to be no natural division of the remaining 152 species. An arbitrary division was made into those found in 14-24 samples and those found in 1-13 samples. The number of species present in each sample for the two categories is given in Figures 5 and 6. There seems to be a general correlation between the number present of the less frequent species of both categories and the number present of the 25 most ubiquitous species. This correlation is weak, however, as is shown when the number of ubiquitous species is plotted against the number of all other species (Fig. 7). It seems clear from Figures 5, 6, and 7 that there is no sharp division of the field for the 152 species which are not among the 25 most ubiquitous. Rather, there seems to be a gradual increase in numbers of species as one approaches the center of the field, and even this trend is far from clear-cut. That the field is not divided sharply for the 14 species occurring in 14 -24 samples is shown in Table VI. The comparison is made in the same manner as that for Table III. The distribution of absences is not significantly different from chance. About all one can say is that a low number of species in the most frequent group is always accompanied by a low number of species in general. The converse is not true.

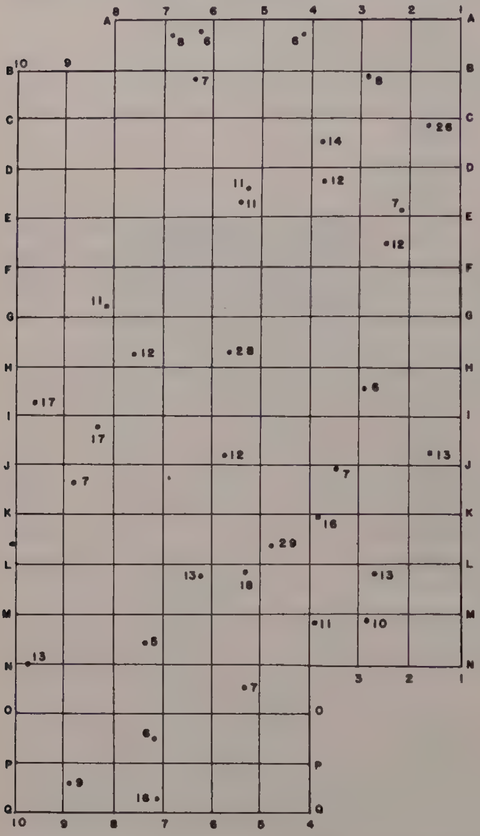

Fig. 6. Locations of 35 samples in the field and the observed number of occurrences of 138 uncommon species.

The foregoing facts seem to indicate that as far as 95 per cent of the soil fauna is concerned, a large area at the center of the field shows remarkable constancy in species composition. The remaining 5 per cent of the individuals, making up 86 per cent of the species present, lends little if anything to the characterization of the community, as is shown by their irregular presence, either as single species or as groups. The tempting conclusion, which remains to be proved, is that this large number of species is not really concerned with any community organization, and, indeed, the whole group might be considered either accidental or transient in occurrence.

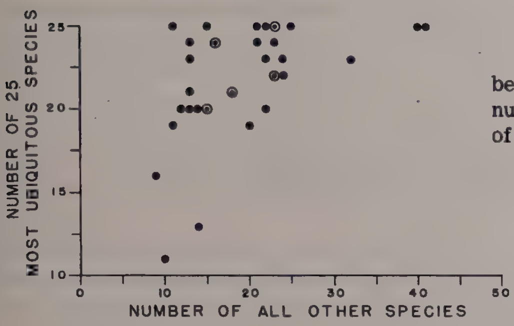

Fig. 7. Relation between the number of 25 common species and the number of all other species in each of 35 samples.

A wide strip along the eastern and southern margins of the field and surrounding the two trees is much less constant in species composition. As mentioned above, a shade line at some critical period seems the most reasonable explanation of this phenomenon, although it is difficult to explain why it should have such a marked effect upon the soil fauna, either directly or indirectly. The strip does not appear to be ecotonal in nature, as evidenced by its failure to show obvious floristic differences from the rest of the field. Moreover, ecotones are generally rich in species, not poor, as is the present case. Whatever the explanation for the existence of this strip, its clear-cut difference from the center of the field precludes the use of the 11 samples taken from it as proper representatives of the field community. In succeeding sections of this

TABLE VI

Comparison of Observed and Expected Frequencies of Absences of 14 Species of Microarthropods in 35 Randomly Collected Samples

Absences	Expected Samples	Observed Samples	d	d^2	d^2/expected
0	0.0279853	0			
1	0.202482	0			
2	0.72953	2			
3	1.74515	0			
	2.70515	2	0.70515	0.49724	0.18381
4	3.11816	4	0.88184	0.77764	0.24939
5	4.43879	7	2.56121	6.55980	1.47784
6	5.24386	3	2.24386	5.03491	0.96015
7	5.28791	3	2.28791	5.23453	0.98991
8	4.64638	8	3.35362	11.24677	2.42050
9	3.61386	0	3.61386	13.05998	3.61386
10	2.51908	2	0.51908	0.26944	0.10696
11 or more	3.42681	6	2.57319	6.62131	1.93221

d.f.:8 chi-square: 10.00242

p approximately 0.24

paper only the 24 samples from the more homogeneous center of the field will be used. The 11 excluded samples have been marked with an asterisk in Table I.

SEASONAL VARIATIONS IN NUMBERS AND VERTICAL DISTRIBUTION

Originally, it was hoped that data on seasonal variations in abundance of different species would yield information useful in attacking the problem of competition between species and ultimately the more general one of maintenance of balance in the community. Viewed from this standpoint, the results are disappointing. The variations in space are almost as conspicuous as those in time and are at least equally valuable in interpreting the community. Twenty-three of 40 species for which adequate data are available show peaks of abundance from November through

TABLE VII

Distribution of Maximum and Minimum Numbers of Common Species of Microarthropods by Date and Sample

Fractions in the "minimum" column reflect ties between samples. Fifteen species were omitted from this column because of multiple ties between samples.

Date	Sample	Species Reaching Maximum	Species Reaching Minimum
Sept. 22, 1949	B4-1450	2	0.4
	D3-2515	0	0.7
Oct. 20, 1949	D1-0623	0	3.4
	E5-3939	1	3.73
Nov. 3, 1949	L4-3616	4	0.0
	M5-1142	0	1.7
Nov. 17, 1949	K3-6010	12	1.0
	M2-1020	0	1.4
Dec. 15, 1949	H7-4526	0	0.0
	F2-2932	2	0.0
Jan. 5, 1950	J8-1142	3	0.5
	M6-1251	1	2.2
Jan. 19, 1950	05-2841	1	1.4
Feb. 18, 1950	H5-4022	0	0.2
Apr. 8, 1950	B6-1410	2	0.7
Apr. 15, 1950	K8-2213	1	4.0
May 6, 1950	B6-1143	2	1.0
May 27, 1950	J5-4616	0	0.0
	I9-4628	0	0.0
June 10, 1950	N7-3742	1	1.0
July 15, 1950	N9-6018	2	0.3
	N2-0310	1	0.3
Sept. 2, 1950	K3-0335	2	0.0
	G8-4853	3	0.0

January (Table VII). The total microarthropod population reflects this trend (Fig. 8). The high point in April is due entirely to an exceptionally high peak in a single species, mite 09. This observation is in agreement with many studies (Macfadyen, 1952) and indicates that these species can continue to multiply at decreasing temperatures until the ground is frozen, or at least that their eggs are able to hatch under these conditions. Once the soil has been frozen for some time, however, nearly all species decline in numbers through the remainder of the winter and do not begin to recover until May or June. Minima occur least frequently in December, September, and February. October has the highest number of species reaching their minimum, followed by April and January. The October minimum occurred in marginal samples (for locations of samples in Table VII, see Fig. 3).

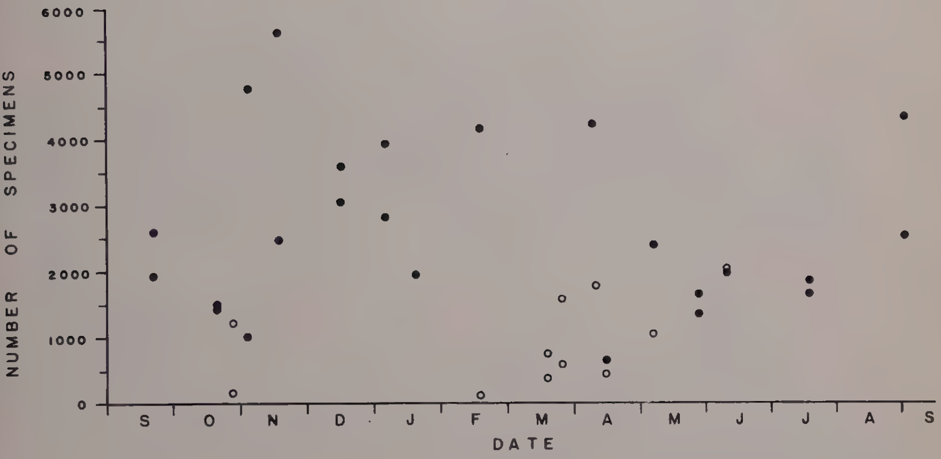

Fig. 8. Seasonal fluctuations in the total microarthropod population. Solid circles represent the 24 samples from the center of the field; open circles represent 11 samples from the edges of the sampled area.

Figures 9 and 10 show examples of species reaching seasonal maxima in late fall or early winter. It seems clear that in such cases soil moisture is of greater importance than temperature as a factor controlling abundance (see Tables VIII and IX). Unfortunately, observations on soil moisture were only begun in January, and comparisons are not available for the preceding autumn. The general correspondence of moisture with abundance of soil arthropods from January through the following autumn cannot be denied, especially when it is remembered that the high moisture contained in the soil in February and March is unavailable because it is frozen. This gives the correspondence a false appearance of a time lag.

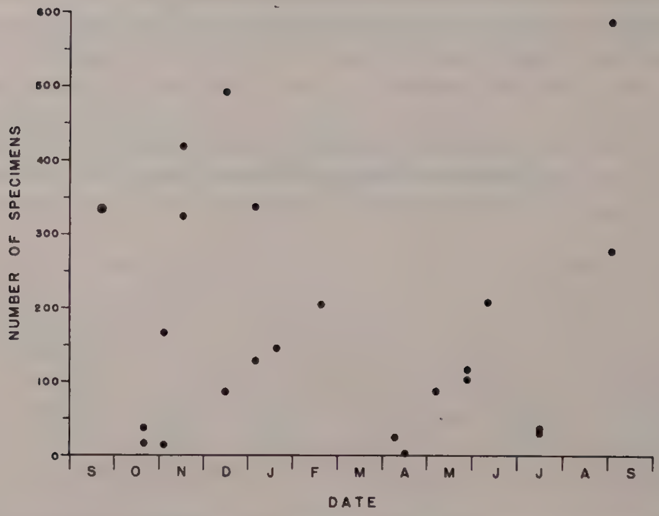

Fig. 9. Seasonal fluctuations in numbers of mite P1, showing peak in late fall and winter.

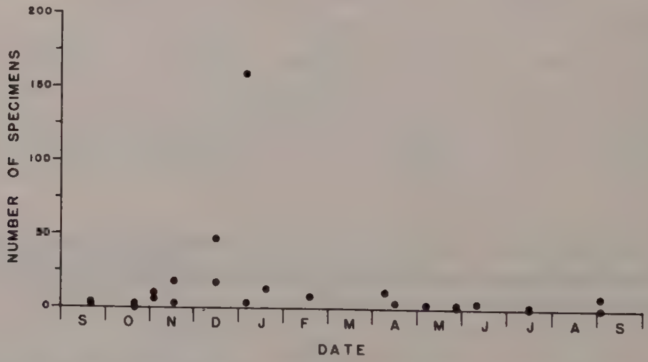

Fig. 10. Seasonal fluctuations in numbers of collembolan P5, showing peak in early winter.

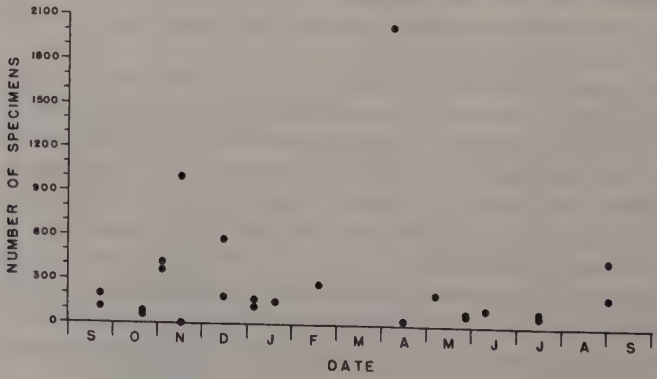

Fig. 11. Seasonal fluctuations in numbers of mite 09, showing peak in spring.

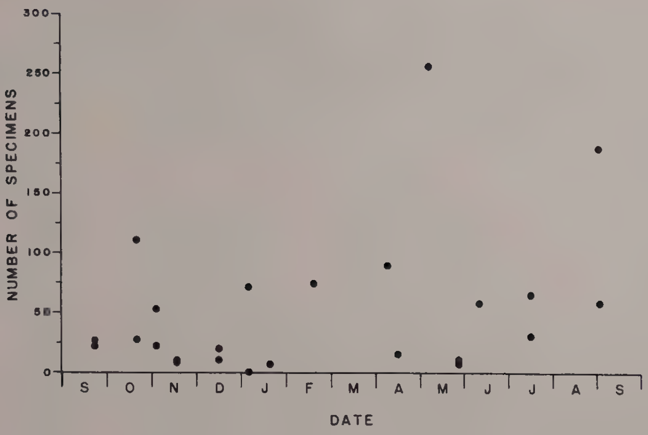

Fig. 12. Seasonal fluctuations in numbers of mite E8, showing peak in spring.

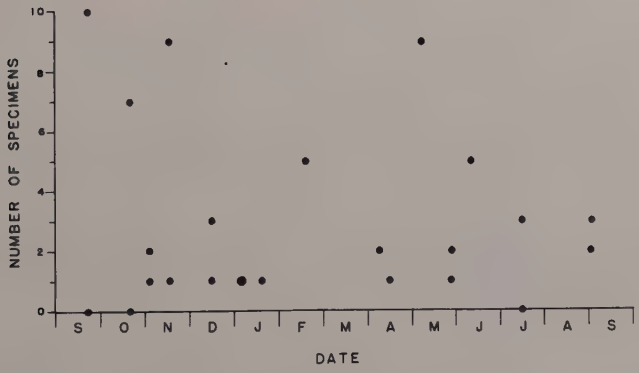

Fig. 13. Seasonal fluctuations in numbers of mite P5, a species that has no discernible peak.

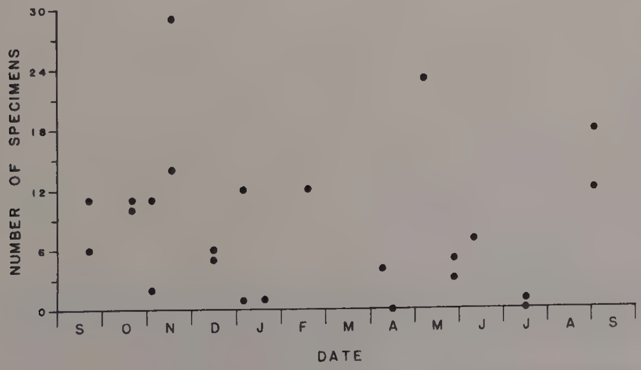

Fig. 14. Seasonal fluctuations in numbers of Protura 1, a species that has no discernible peak.

Some numerically important species do not show the foregoing pattern of a fall high and spring low. Mites 09 and E8 (Figs. 11, 12) have peaks of abundance in the spring, and several among the 25 most ubiquitous species apparently have no particular season of maximum abundance (Figs. 13, 14).

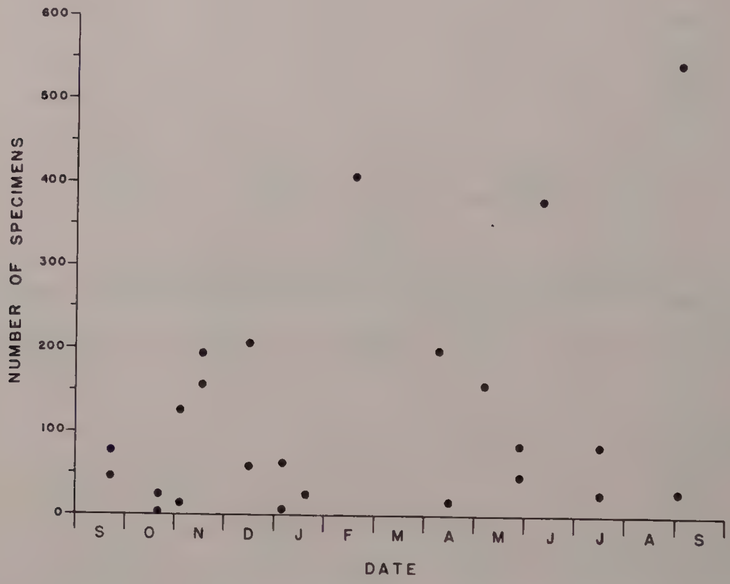

Fig. 15. Seasonal fluctuations in numbers of mite 05, showing a continuous rise during the year of observation.

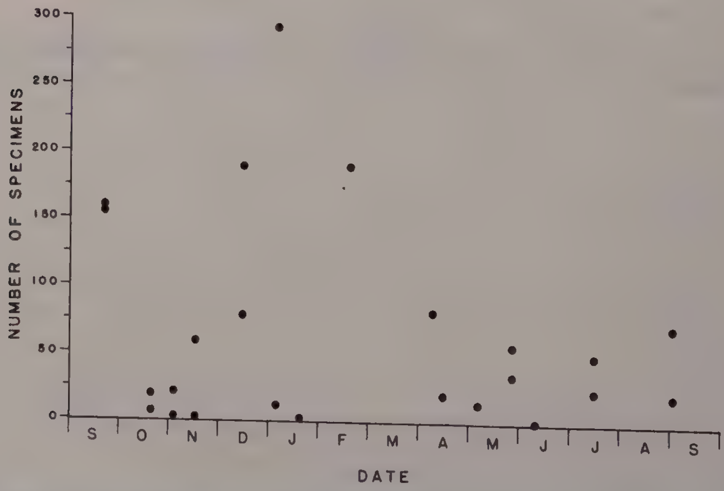

Fig. 16. Seasonal fluctuations in numbers of mite 08, showing a continuous fall during the year of observation.

TABLE VIII

Soil Temperatures at Two Depths

All readings Fahrenheit.

Depth in Inches	September			October				November			December				
	9	15	22	6	13	20	27	3	10	17	1	8	15	22	29
1.5	63	59.5	64	60	59	66	51	43	51	44	32	32	28	44	33
8.5	61	61	62	59	58	58	49	46	48	45	36	35	34	43	36
Frozen Soil												1.5	2.5		

Depth in Inches	January				February				March		
	5	12	19	25	1	11	18	25	4	15	25
1.5	33	32	26	36	32	33	32	31	31	33	36
8.5	38	34	32	33	33	34	33	33	32	32	33
Frozen Soil		1.5	8	5	4	4	3	3	8	8.5	8

Depth in Inches	April				May				June		
	8	15	22	29	6	13	20	27	3	10	24
1.5	44	39.5	49	50	58	61	69	60	61	78	81
8.5	40	36	42	45	55	56	61	61	62	68	72

Depth in Inches	July					August				September
	1	8	15	22	29	5	12	19	26	2
1.5	71	78	75	72	87	85	77	71	74	68
8.5	66	72	73	68	74	74	67	69	72	68

Of considerable interest are species that show continuous rise or fall over the year (Figs. 15, 16). Whatever the unknown factors that control them, such species are less affected by immediate weather changes than are those having an identifiable annual cycle in numbers. In these cases it is clear that a reasonable understanding of populations will come only after studies have continued over a period of years.

Many species of microarthropods do not remain at the same level in the soil throughout the year; this is especially true of those characteristic of the layers below the turf. All of these species show a movement to the turf in spring and early summer. Figures 17-20 show typical and extreme cases of the vertical movement of the bulk of the population. Each species shows a downward movement, usually beginning in July, that is often more gradual than the upward trend.

The migration into the turf is probably stimulated by temperature changes, since it begins at about the time when the soil temperature gradient is being reversed. The temperature reversal occurred during the last week in March, preceding the observed upward migration by one to three weeks (Table VIII). The spring thaw accompanied the temperature reversal, of course, and the water thus freed may have been a factor in initiating some of the migration. Table VIII shows the occurrence and depth of frozen soil. Temperature may also provide the stimulus for the return of these species to the deeper levels, although the downward migration begins before summer temperature maxima are reached. It seems at least as likely, moreover, that the increasing dryness of the summer, especially in the turf, is responsible for the descent, but the case for soil moisture is not unequivocal, as it drops more or less regularly throughout both upward and downward migrations (Table IX). Strickland (1947) attributed the annual migration that he found in Trinidad to changes in rainfall and humidity.

The reason for these migrations is not clear. One more or less automatically expects seasonal migrations to be associated with reproduction, but in the present case there seems to be no relation between the presence or absence of vertical migration and the presence or absence of any kind of seasonal cycle in numbers. Of 15 species showing fall or winter peaks in numbers, seven have an identifiable migration and eight do not; of eight species having no clear cycle in numbers, four migrate and four do not.

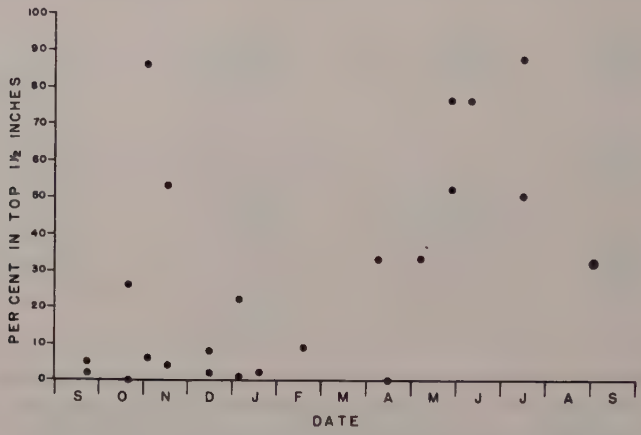

Fig. 17. Vertical migration of mite P1 in the soil.

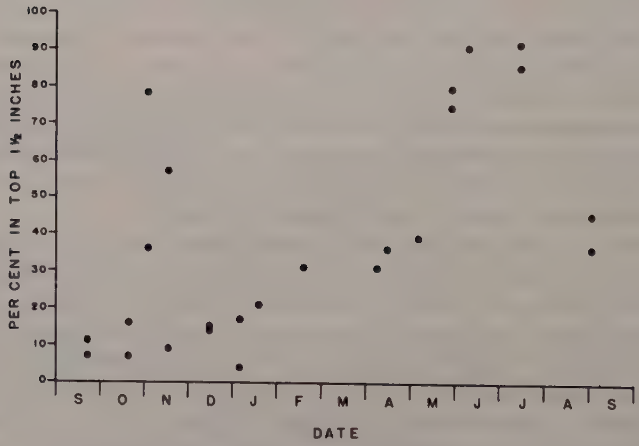

Fig. 18. Vertical migration of mite 01 in the soil.

For eight species the migration carries enough individuals below the standard collecting depth to create a false impression as to numerical abundance. The most striking example of this is Japygid 1. To judge from the standard samples, this species appears to have two peaks of abundance, a low one in November and a much higher one in June (Fig. 21). When the figures from the four complete samples are examined

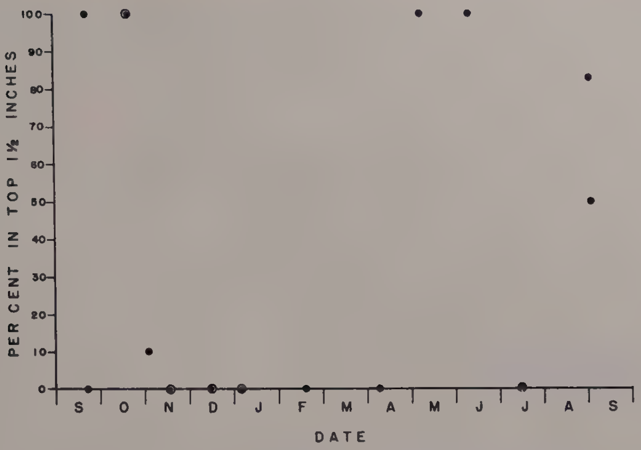

Fig. 19. Vertical migration of Protura 2 in the soil.

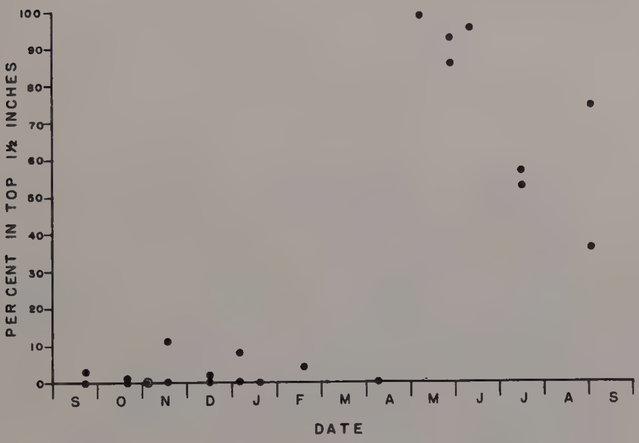

Fig. 20. Vertical migration of collembolan P1 in the soil.

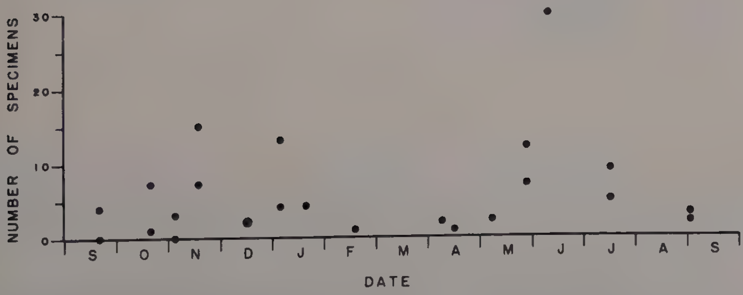

Fig. 21. Seasonal fluctuations in numbers of Japygid 1 in the top 8.5 inches of soil. Note two well-defined peaks.

TABLE IX

Soil Moisture at Three Depths, January 25 - September 2, 1950

(In per cent of wet weight.)

Depth in Inches	January	February				March		
	25	1	11	18	25	4	18	25
0 - 1.5	20.8 22.4	22.9 21.5	28.3	25.7 28.9	34.8	38.5	32.2 36.8	21.5 28.8
1.5 - 5	15.6 16.5	9.7 18.7	16.6	15.1 12.5	12.8	25.1	16.8 19.6	18.9 19.4
5 - 8.5	12.4 11.4	6.5 8.7	8.4	9.0 7.7	9.6	10.6	12.7 11.9	11.1 10.2

Depth in Inches	April				May			
	8	15	22	29	6	13	20	27
0 - 1.5	26.0 13.5	13.1 8.5	13.2	12.3 10.8	11.3 7.8	8.3 9.8	5.1	12.2 11.3
1.5 - 5	8.8 10.6	10.3 6.4	9.9	9.3 8.6	8.1 6.1	8.2 8.0	2.9 5.4	9.9 9.6
5 - 8.5	7.5 10.5	9.3 6.2	9.6	9.3 7.7	8.7 6.3	7.7 7.4	2.6 8.3	10.0 9.5

Depth in Inches	June			July				
	2	10	24	1	8	15	22	29
0 - 1.5	11.9 10.3	11.7 7.9	20.8 9.5	6.7 8.7	4.8 5.2	3.5 2.3	10.3 9.3	3.7 2.9
1.5 - 5	10.6 9.0	6.6 6.6	9.4 9.4	5.7 7.6	5.8 6.0	4.6 3.3	8.2 8.7	4.3 5.3
5 - 8.5	10.3 9.1	6.1 7.0	9.4 8.7	6.0 7.2	5.8 5.7	5.9 3.9	8.0 9.1	4.8 6.2

Depth in Inches	August				September
	5	12	19	26	2
0 - 1.5	2.0 2.1	10.0	7.5 5.5	3.9 2.6	9.5 8.4
1.5 - 5	3.9 2.2	8.7	6.4 5.2	4.5 4.1	7.8 7.3
5 - 8.5	4.6 2.8	8.7	6.0 5.4	5.3 4.5	6.9 6.5

(Table II) and considered in conjunction with the data on vertical distribution, an entirely different concept of the seasonal abundance is obtained (Fig. 22). There is only one peak of abundance, which comes in November. The early summer "peak" is apparently due entirely to the appearance in the upper five inches of a number of specimens that have been below the standard collecting depth and have been missed in all samples except the deep ones of November, February, and April. We believe that the migrational phenomenon involved here is the explanation for the two peaks found for several species by Strenzke (1951) since his

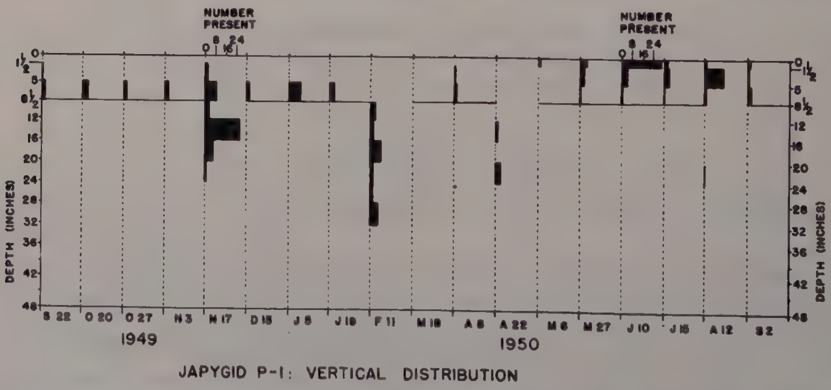

Fig. 22. Vertical distribution of Japygid 1 in all samples, including 4 deep ones. Note effect of vertical movements on apparent abundance in top 8.5 inches.

findings are at variance with the results of most other studies (Macfadyen, 1952). Dowdy (1944) has described vertical movements of this sort for macroscopic invertebrates, but they were mostly sharp descents in January with a quick return to the upper layers. Other similar findings are cited by Macfadyen.

RELATIONSHIP BETWEEN NUMBERS OF INDIVIDUALS AND OF SPECIES

Since the community concept began to take form, there have been attempts to find some constant numerical relationship between the species in a community. Earlier attempts (Raunkiaer and others) centered on the frequency of occurrence of various species. More recently, use has been made of numerical abundance rather than frequency. These later analyses have been based largely upon groups of species that were related taxonomically (moths in a light trap, birds in a valley) rather than upon species that might be presumed to be related ecologically. The same criticism holds to a certain extent for the present study, as the collecting technique is worthless for organisms other than microarthropods. The animals concerned were removed from known volumes of soil, however, and were not drawn in from surrounding and ecologically divergent territory. Since they came from the same place, they may be assumed to have some ecological relationship to one another (Dice, 1952: 15).

There can be no doubt of the value of a system that will describe mathematically the relationship between the number of species and the number of individuals in a natural situation. Two uses of such a system may be mentioned: One would be a completely unbiased method for comparing different localities in terms of general biotic composition; the other would be that with an adequate (and possible) sample, an accurate prediction could be made of the total number of species in a biological universe, to borrow Preston's term (1948). Our data lend themselves readily to such an analysis. Indeed, we have used a modification of the Raunkiaer curve in analyzing the distribution of organisms on the field. This curve, however, is generally recognized to be of little value in comparing samples of different sizes and does not properly allow for species with strongly clumped distributions. Both the logarithmic series, devised by Fisher and Williams, and the lognormal curve, applied by Preston, take into account the numerical abundance of each species. The results of analyzing our data by these two methods may now be considered.[1]

---

[1] If the papers of Williams (1953) and Brian (1953) had been available at the time of writing, this section of our paper would have taken a different form, but the conclusions would not be altered. Williams concedes that the logarithmic series is less useful than the lognormal. Concerning Brian's contention that the form of the curve is nearer to the negative binomial than to the lognormal, we agree that this is probably true, but the difficulty presented by the nonconformity of samples of different sizes (Fig. 24) remains. This nonconformity is also evident, though less conspicuous, in Williams' chart of light-trap data (loc. cit., p. 23).

Logarithmic Series

Fisher, Corbet, and Williams (1943) presented a mathematical analysis of data involving a collection of Malayan butterflies, and of Lepidoptera caught in a light trap at Harpenden, England. They found that the relation between the number of species and the number of individuals could be expressed by the following equation:

$$S = \alpha \log_e(1+\frac{N}{\alpha})$$

In this equation S is the number of species in the sample, N, the number of individuals, and alpha is a constant that is most easily obtained from Fisher's table (1943). The constant alpha represents an index of diver-

TABLE X

The Index of Diversity (Alpha) for Samples of Three Different Sizes Obtained by Lumping Randomly Drawn Pairs, Groups of Five, and Groups of Twelve Single Samples

	Sample	Date	Species in Group	Individuals in Group	Alpha for Group
Pair 1	J8-1142 M5-1142	Jan. 5, '50 Nov. 3, '49	64	4,999	10.3464
Pair 2	N2-0310 05-2841	July 17. '50 Jan. 19, '50	52	3,661	8.584
Pair 3	K3-6010 K3-0335	Nov. 17, '49 Sept. 2, '50	59	8,197	8.537
Pair 4	M5-1142 D1-0623	Nov. 3, '49 Oct. 20, '49	71	2,529	13.568
Pair 5	J5-4616 K8-2213	May 27, '50 Apr. 15, '50	53	2,326	9.659
Ave. value for 5 pairs					10.139
Group 1	K8-2213 B6-1143 N2-0310 M2-1020 K3-6010	Apr. 15, '50 May 6, '50 July 17, '50 Nov. 17, '49 Nov. 17, '49	92	12,880	13.424
Group 2	K3-6010 05-2841 K3-0335 G8-4853 I9-4628	Nov. 17, '49 Jan. 19, '50 Sept. 2, '50 Sept. 2, '50 May 27, '50	86	15,948	11.955
Ave. value for 2 groups					12.690
Group 1	(alternate samples, beginning with B4-1450 in Table I; samples marked with asterisk omitted.)		123	34,056	16.0679
Group 2	(alternate samples, beginning with D3-2515 in Table I.)		124	30,178	16.5205
Ave. value for 2 groups					16.3621

sity; a large value indicates a large number of species in relation to the number of individuals and hence a greater diversity in the biota. Perhaps the greatest advantage claimed was that the value of alpha remained constant for any adequate sample drawn from the same population of species. Thus, the biota (or any comparable parts) from different localities could be compared in a convenient objective manner. The value of alpha, therefore, was calculated for each of our samples. The values ranged from 5.42 to 11.36, with a mean of 7.89. They showed no seasonal trend, and although the mean for the 24 samples in the center of the field (see above) was higher than for the 11 samples more or less peripheral in location, the difference was not significant. When the 24 samples were lumped and considered as a single sample, however, the value of alpha was 19.315, or more than twice the mean value for individual samples. On further analysis it was found that pairs of samples, drawn at random from the group of 24, gave an average of 10.139; groups of 5 samples, an average of 12.69; and groups of 12, an average value of alpha of 16.36 (Table X). Thus, for our samples the value of the constant is clearly related to the size of the sample. In fact, this relationship is remarkably close to a straight line on a log-log plot of alpha against sample size (Fig. 23). In view of the claims of Fisher, Corbet, and Williams, this finding is unexpected, and only two explanations seem tenable at present:

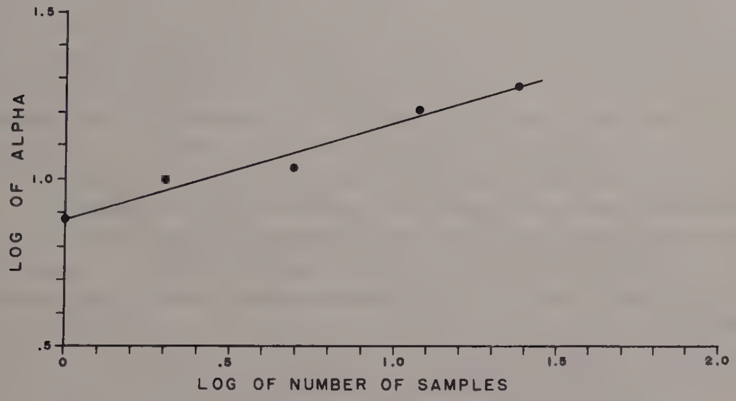

Fig. 23. Relation between the index of diversity and sample size.

(1) The community being sampled is found to be increasingly heterogeneous as larger and larger samples are drawn from it, that is, new species are added relatively faster than new individuals; (2) the formula employed does not properly express the relationship in question. Since the 24 samples used were deliberately selected for uniformity of species composition, the second alternative seems the more likely. In an effort to obtain further evidence, the following analyses were performed:

1. The two pairs of samples taken closest together in both space and time were selected as the pairs most likely to show the greatest uniformity of faunal composition. Accordingly, if the fact that increasing the

number of samples raises alpha is a reflection of the increasing distance between samples in space and time, these two pairs should give lower values of alpha than pairs selected at random. Such, however, is not the case. Two samples taken August 12 and September 2, 1950, on the same 60-foot square (K3) gave a value of 10.61 when lumped together, and a pair taken November 3, 1949, on adjacent squares L4 and M5 gave a value of 13.12 when combined. These two values of alpha are above the average for randomly combined pairs, although both are within the total variation of such pairs (Table X). The hypothesis that the field shows more and more heterogeneity with increasing sampling is not confirmed by the foregoing observation.

2. A second approach toward more homogeneous material was to consider only the species characteristic of the soil below the turf in the 24 samples. The turf constitutes a barrier against any stray individuals from other communities. One might thus be reasonably certain that practically all organisms collected below this stratum would be true constituents of the field community. An increase in the size of the sample should not affect the relationship between numbers and individuals as long as the samples are drawn from the central part of the field. If the logarithmic series were a true approximation of the relationship between species and individuals, the value of alpha should be the same for large and small samples. The values for this constant are lower for the soil below the turf than for the total soil, since few species occur below 1.5 inches, and these occur in large numbers. The average sample gave an alpha of 2.82; the 24 samples lumped gave an alpha of 3.87. The difference between these two figures is greater than it should be, since for samples of this size the error of alpha should be between 5 and 10 per cent (Fisher, Corbet, and Williams, 1943). Again, the index of diversity is directly related to sample size, and we reject the hypothesis that the relationship is due to increasing heterogeneity.

It is worth noting that these comments were written prior to the publication of the analysis of Myers and Chapman (1953), who found that the logarithmic series had no practical application to the plant community that they studied.

Lognormal Distribution

In discussing the logarithmic series Preston (1948) pointed out that this method assumes that the lowest category (the number of species represented by one individual) is the most numerous regardless of sample size. Carried to its extreme, with the world biota as a sample, this assumption is of course preposterous. There must be relatively few species so close to extinction. On a smaller basis it remains a possibility, as strays may make up a sizable fraction of the species present in many samples. We agree with Preston, however, that in a biological universe extremely rare species are probably comparable in numbers to the extremely abundant ones and that most species are intermediate in numerical representation. Preston concluded that the relations are adequately described by a Gaussian curve, when the ordinate is on a scale of $\log_2$. Thus, doubling the sample size moves the curve one unit to the right and reveals a larger fraction of the same curve. The formula for this curve is:

$$S_r = S_o e^{-(ar)^2}$$

S_o is the number of species at the mode of the curve (maximum number of species represented numerically between any successive powers of 2); these spans of numbers between successive powers of 2, the units on the ordinate, are called octaves. Thus, S_o is the number of species in the modal octave; S_r is the number of species r octaves from the mode; e is the base of natural logarithms; a is a constant. After applying this formula to a number of biological universes, Preston concluded that the constant a is nearly always close to 0.2 and that the mode of the curve usually falls within a few octaves of 2^5 individuals for relatively complete data.

The application of this type of analysis demands very large samples, since the height of the mode is determinable only by observation, and at least one octave below the modal octave must be observed before the mode can be located with any confidence. In our data only the organisms below the turf yielded a sufficiently large number of individuals in relation to the number of species. Upon plotting the total number of organisms below 1.5 inches (Fig. 24), we find a reasonably good fit with the lognormal curve for $S_o = 4$; $a = 0.16$. According to expectations, then, the average sample would follow the same curve, starting 4.5 octaves to the right of the total curve, since the average represents 1/24 of the number of individuals of the total. That such is not the case can be seen in Figure 24. Again, a reasonable fit to a lognormal curve exists, but the two curves do not coincide. It should be emphasized that an increase in sample size moves the mode of the curve up and to the left. Since the area under the curve represents the number of species present, it is

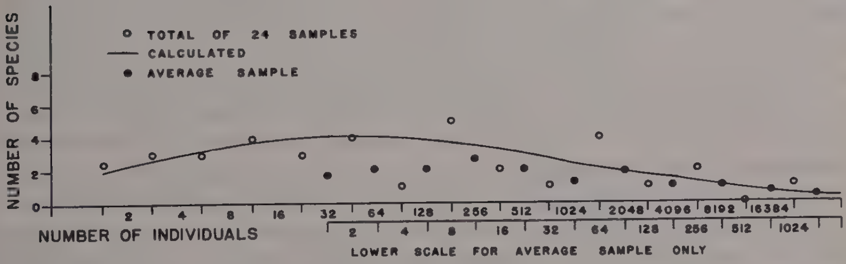

Fig. 24. Application of the lognormal curve to the total population below 1.5 inches in 24 samples and to the average of these samples.

clear that increasing the sample size has increased the apparent heterogeneity of the field. The lognormal curve, then, also fails to describe the relation between individuals and species for samples of different sizes. This is the test that any mathematical system must pass, if it is to be useful to ecologists, and no such system is forthcoming as yet. A little reflection will suffice to show why the devising of such a system is likely to be unrewarding. In all of these mathematical systems it is assumed that one curve will describe the cumulative distributions of individual species, a situation that could obtain only if all of the species involved had the same kind of distribution. Individuals of different species are not distributed in the same manner in space. To take extreme examples, ants have a strongly "clumped" distribution, while many birds, because of their territoriality, have a nearly even distribution within suitable habitats. To add the two distributions is not valid, although doubtless some sort of curve could be drawn that would describe the situation mathematically.

We may now consider why an increase in sample size apparently increases the heterogeneity of a biological universe, even within the same universe. If, in general, the most numerous species are those with a more or less random distribution, or if they are sufficiently numerous that any clumping does not result in their absence from a large number of samples, then an increase in the number of samples will not have any effect upon a curve describing their distribution. With rarer species, however, clumping becomes an important factor as the curve expands. If the rare species are strongly clumped, adding samples will be more likely to add new species rather than individuals of species already recorded. With the total number of individuals increasing at an approximately even rate, the fauna will appear to become more diversified because of this effect of the clumping of rare species. It is easy, though somewhat tedious, to estimate the degree of clumping for reasonably abundant species (those occurring in more than half of the samples). It is most conveniently done by applying the negative binomial distribution (Anscombe, 1949). The value of the constant k decreases as the degree of clumping increases and in the logarithmic series assumes a value of 0. As an example of the application of the negative binomial in a species that shows neither random distribution nor extreme clumping, Protura 2 has been selected. In this case k has a value of 0.915. Comparing the theoretical with the observed distribution (Table XI), we find a satisfactory agreement; chi-square is 4.79 with 6 degrees of freedom at the 95 per cent confidence limit. Unfortunately, the value of k cannot be estimated with any reasonable confidence for the rare species, and hence no comparison can be drawn with more abundant ones. It can, however, be demonstrated that many of these rare species are clumped and without recourse to complex statistical manipulations. Of the 38 species represented by a total of 2, 3, 4, or 5 specimens each, 13 (slightly over one-third) have the most strongly clumped distribution possible, with all specimens in one sample out of 24 (Table XII). In addition, the table shows that fewer than half of the species have the most probable distribution, based on an assumption of randomness. Although only the species

TABLE XI

Application of the Negative Binomial Distribution
to the Observed Distribution of a Species
of Protura in 24 Soil Samples

Number per Sample	Observed Samples	Expected Samples	Difference Squared / Expected Samples
0	7	7.116	0.00189
1	4	4.7868	0.1293
2	4	3.3695	0.11798
3	5	2.40697	2.79347
4	1	1.73193	0.30932
5	0	1.2516	1.2516
6 plus	3	2.3372	0.18976
	d.f.:6	chi-square:	4.79152

represented by a total of 2-5 specimens are included in Table XII, a perusal of Table I will serve to confirm the marked clumping of the infrequent species. Of course, nothing can be said of the 45 species represented by one specimen each.

We consider that the foregoing facts adequately support our hypothesis that the less common species are sufficiently clumped to give the impression of an increasing heterogeneity with increasing sample size, when all species are treated on a single distribution curve.

The easiest curve of this sort to understand is the "species-area" curve, widely used by plant ecologists. Applied on an arithmetical scale, this curve appears to be approaching an asymptote at about 38-40 species for soil arthropods below the turf (Fig. 25). On a scale using logarithms of the sample size, the relationship is apparently a straight line, with no hint of a bend at either end (Fig. 26). An extrapolation downward predicts a sample containing no species at a size between 1/16 and 1/32 of the standard sample, but the minimum number of

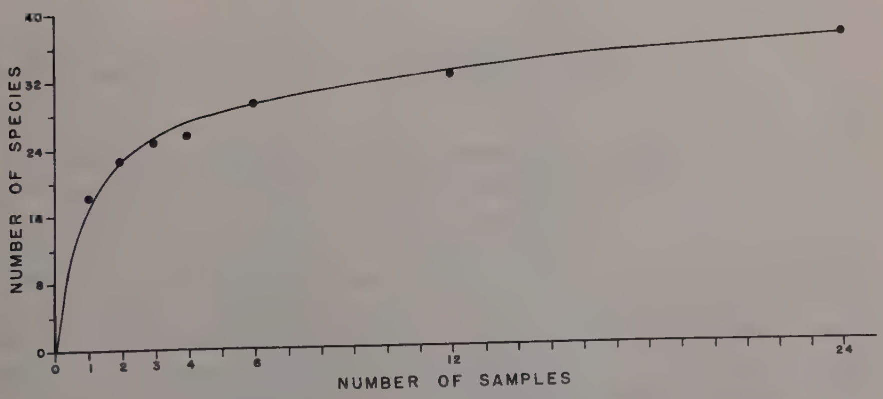

Fig. 25. Species-area curve for soil arthropods below 1.5 inches.

TABLE XII

The Distribution of 38 Rare Species of Soil Arthropods in 24 Samples

Individuals Per Species	Species	All Specimens Separate	Species Having These Distributions								All Specimens in One Sample
			1-2	1-1-2	1-1-1-2	1-3	1-1-3	2-2	2-3	1-4	
2	21	12*	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	9
3	4	2*	2	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0
4	6	0*	. . .	2	. . .	0	. . .	1	. . .	. . .	3
5	7	0*	. . .	. . .	2*	. . .	2	. . .	0	2	1

*Most probable distribution, assuming randomness; the two distributions marked for 5 specimens have an approximately equal probability.

individuals below the turf in any of the 24 samples is 152, and the mean number is 1333.5. Thus, the most probable size of a sample that would be expected to be negative could hardly be larger than 1/152 - 1/1300 of the standard, and therefore the curve must bend to the left at its lower end, as suggested in Figure 26.

Must it also bend to the right to give an upper asymptote, as Preston states? Only observation can answer the question, of course, but logic suggests that the curve should flatten before the limit of the community is reached. In any case, the point of its bend must be found, or the entire community must be counted before one can devise a satisfactory mathematical system to describe the relationship between the number of species and of individuals. In the case of the community under consideration, a search for the upper asymptote seems impractical. Perhaps less complex communities could be found in which such an approach would be feasible. If so, this would be a fruitful field for investigation.

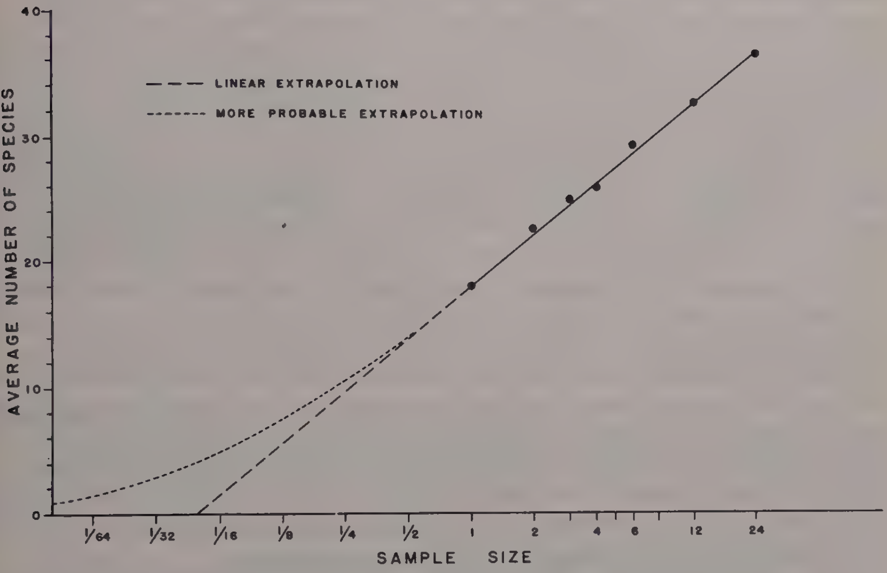

Fig. 26. Species-area curve for soil arthropods below 1.5 inches, with the ordinate in logarithms of sample size. Two theoretical extrapolations.

It is not surprising that the less common species should be clumped in any natural community. The very fact of their rarity suggests that conditions are not suitable for them everywhere in the community, either in space or in time. In a randomly drawn set of small samples it is not unreasonable to suppose that suitable conditions for such a species would be encountered infrequently, or not at all. Moreover, different samples would be likely to contain suitable conditions for different rare species. On this view, the more abundant species would be those finding conditions more or less favorable over much or all of the community or of a particular stratum. This supposition regarding the difference in status between common and rare species is confirmed in the present study in the distribution of the 25 most ubiquitous species, where absences of different species are correlated, indicating a major change in over-all conditions in the soil.

SUMMARY AND CONCLUSIONS

As an approach to the complex problem of analyzing a natural community, the small arthropods of the soil of an abandoned field were sampled over a period of one year. Admittedly a small segment of the community, they nevertheless provided ample complexity, as attested by the fact that 74,572 were counted from 35 soil samples. This rather staggering total contains 177 kinds, not taxonomically identified, but assumed to be equatable with species. The individuals are distributed among the species in such a fashion that the 25 species found in 25 or more samples account for 95 per cent of the specimens. There is evidence that these 25 species may form an ecologically closely interrelated group. For any sample there is a strong tendency for all or nearly all to be present, or for five or more to be absent. The samples with the complete set of 25 species occupy the center of the field; those lacking five or more are related to the sides of the field and to the two large hickory trees on it. We consider that the peripheral area, which is not obviously different from the center, has conditions sufficiently different to upset the ecological relationships among these 25 species and to preclude the use of the 11 samples taken from it. The larger central area is evidently more homogeneous as far as 95 per cent of the microarthropods are concerned.

Within the central area, the microarthropods are most abundant in the turf but occur as deep as 39-42 inches in the soil. Seasonal maxima occur typically in late fall or early winter, with minima in April, although there are exceptions. Many species have a vertical migration, the bulk of the population moving upwards in April or May and descending in July or August. Moisture and temperature are interrelated with both fluctuations in numbers and vertical movements.

The uniformity of the center of the field for the relatively few ubiquitous and common species is emphasized in a consideration of mathematical analysis of the relationships between species and individuals. Because results of these analyses are all related to sample size, none is of value in interpreting the community. The reason for their failure is illuminating, however. The clumping of the rare species causes each system tc reveal an increasingly heterogeneous community as sample size is enlarged, or as new samples are added. This is because new species are more likely to be added than more specimens of species already found. Thus, the mathematical models fail to represent the community accurately, but the clumping of the rare species shows that the community is far from uniform for them.

Once again, then, there emerges a clear difference between the common species and the rare ones. The former, by their ubiquity and abundance, characterize the community and give it a fundamental unity that is obscured by the large number of rare species, each of which may find suitable conditions in only a few restricted places in the community. The less common species of microarthropods, then, would be quite similar to the less common species of plants, which are also clumped in distribution and which, because they are conspicuous, have attracted considerable attention to the "mosaic" nature of the community (Evans and Cain, 1952). We agree with most other workers that the rare species have little to do with community organization, being insignificant numerically, whereas the relatively few ubiquitous species give the community its characterization and are essentially responsible for its biological activity.

LITERATURE CITED

The literature on soil microarthropods is much more extensive than the cited papers would indicate. Because our results are in general agreement with those of most other authors and because we have made different uses of the data, only a few of the many excellent papers on the subject have been listed. The reader interested in obtaining a more complete bibliography is referred to the papers by Macfadyen (1952) and especially Fenton (1947).

ALLEE, W. C., A. E. EMERSON, O. PARK, T. PARK, and K. P. SCHMIDT.

1949 Principles of animal ecology. Philadelphia and London: W. B. Saunders Co.

ANSCOMBE, F. J.

1949 The statistical analysis of insect counts based on the negative binomial distribution. Biometrics, 5: 165-73.

BRIAN, M. V.

1953 Species frequencies in random samples from animal populations. Journ. Animal Ecol., 22: 57-64.

CAIN, S. A., and F. C. EVANS

1952 The distribution patterns of three plant species in an old-field community in southeastern Michigan. Contrib. Lab. Vert. Biol. Univ. Mich., 52: 1-11.

DICE, L. R.

1952 Natural communities. Ann Arbor: Univ. Mich. Press. Pp. i-x + 547, 52 figs.

DOWDY, W. W.

1944 The influence of temperature on vertical migration of invertebrates inhabiting different soil types. Ecology, 25: 449-60.

EVANS, F. C.

1952 The influence of size of quadrat on the distributional patterns of plant populations. Contrib. Lab. Vert. Biol. Univ. Mich., 54: 1-15.

EVANS, F. C., and S. A. CAIN

1952 Preliminary studies of the vegetation of an old-field community in southeastern Michigan. Contrib. Lab. Vert. Biol. Univ. Mich., 51: 1-17, 2 pls.

FENTON, G. R.

1947 Essay review. The soil fauna: with special reference to the ecosystem of forest soils. Journ. Animal Ecol., 16: 76-93.

FISHER, R. A., A. S. CORBET, and C. B. WILLIAMS

1943 The relation between the number of species and the number of individuals in a random sample of an animal population. Journ. Animal Ecol., 12: 42-58.

HOFFMANN, C. H., H. K. TOWNES, H. H. SWIFT, and R. I. SAILER

1949 Field studies on the effectiveness of airplane applications of DDT on forest invertebrates. Ecol. Monogr., 19: 1-46.

MACFADYEN, A.

1952 The small arthropods of a Molinia fen at Cothill. Journ. Animal Ecol., 21: 87-117.

MYERS, E., and V. J. CHAPMAN

1953 Statistical analysis applied to a vegetation type in New Zealand. Ecology, 34: 175-85.

PEARSE, A. S.

1946 Observations on the microfauna of the Duke Forest. Ecol. Monogr., 16: 127-50.

PRESTON, F. W.

1948 The commonness, and rarity, of species. Ecology, 29: 254-83.

SALT, G.

1952 The arthropod population of the soil in some East African pastures. Bull. Entomol. Res., 43: 203-20.

SALT, G., F. S. J. HOLLICK, F. RAW, and M. V. BRIAN

1948 The arthropod population of pasture soil. Journ. Animal Ecol., 17: 139-50.

SCHMIDT, K. P.

1946 The new systematics, the new anatomy, and the new natural history. Copeia, 1946, pp. 57-63.

STRENZKE, K.

1951 Die Biozönotik der Oribatiden norddeutscher Böden. Naturwissenschaften, 38: 284-85.

STRICKLAND, A. H.

1947 The soil fauna of two contrasted plots of land in Trinidad, British West Indies. Journ. Animal Ecol., 16: 1-10.

SVERDRUP, H. U., M. W. JOHNSON, and R. H. FLEMING

1946 The oceans; their physics, chemistry and general biology. New York: Prentice-Hall.

WILLIAMS, C. B.

1953 The relative abundance of different species in a wild animal population. Journ. Animal Ecol., 22: 14-31.

WILLIAMS, E. C.

1941 An ecological study of the floor fauna of the Panama rain forest. Bull. Chicago Acad. Sci., 6: 63-124.

Copies of this contribution may be purchased from the University of Michigan Press, Ann Arbor, Michigan. Price, $0.75.